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LABORATORY EXERCISES IN CHEMISTRY

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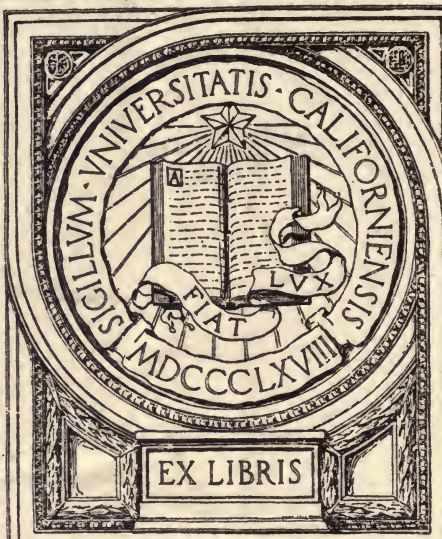

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LABORATORY EXERCISES

FROM

THE "ESSENTIALS OF CHEMISTRY"

BY

JOHN C. HESSLER, PH.D.

PROFESSOR OF CHEMISTRY, THE JAMES MILLIKIN UNIVERSITY; LATE INSTRUCTOR IN CHEMISTRY, THE UNIVERSITY OF CHICAGO, AND THE HYDE PARK (CHICAGO) HIGH SCHOOL

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REVISED (1912)

BY

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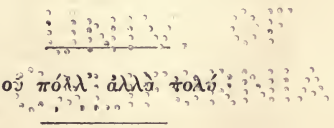

BENJ. H. SANBORN & CO.

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1912

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TO MY
MOTHER

The Fort Hill Press
SAMUEL USHER
176 TO 184 HIGH STREET
BOSTON, MASS.

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PREFATORY NOTE.

These laboratory exercises form a part of the "Essentials of Chemistry," and contain specific directions for laboratory work. All the exercises are intended *for the student*, and are so arranged that they may be used in schools having either one-hour or two-hour laboratory periods.

The experiments require only **common materials** and **simple apparatus.** The quantities of materials have been stated definitely and accurately. Where possible, the directions call for fractional parts of a test tube, so that unnecessary weighing may be avoided. The test tube meant is the ordinary $5 \times \frac{5}{8}$ inch tube found in most laboratories.

In the revised edition of the laboratory exercises the order of the experiments has been altered to bring it into harmony with the revised text. Many of the experiments have been rewritten, and several new ones have been added. The *quantitative* exercises are not numerous. They have been selected for their importance in showing the weight relations of chemical reactions. All have been thoroughly tested, and have succeeded in the hands of *average* students. For the *earlier* quantitative experiments the **object** of the experiment and the **method** used have been described briefly at the beginning of the exercise, so that the student may have a better appreciation of the directions he is to follow and of the result sought.

The reviser will be glad to learn of any errors that may exist in the exercises, and to receive suggestions from persons interested.

AUGUST, 1912. J. C. H.

LABORATORY DIRECTIONS.

(*For the Student.*)

1. Provide yourself with an apron and a pair of sleeves (rubber is the best material for these); also with soap and towel, and a white cloth about a yard square. The cloth is to be used for wiping apparatus.

2. Work by yourself; and give *your own* descriptions, observations, and calculations, not those of *another*.

3. Record *at once* all the observations you make in connection with an experiment. See that your notes contain the answer to every question, direct or implied, that occurs in the laboratory exercise. Write neatly and distinctly. If the notes of two experiments occur on the same page, separate them by at least two centimeters of space.

4. Have a place for everything. Throw away nothing until you are sure you are through with it. Throw nothing but liquids into the sink. Put other waste materials into the proper receptacle.

5. If an experiment is unsatisfactory, repeat it until you are successful; but *first* learn the probable cause of your error.

6. When you enter the laboratory, examine your table, and see that everything has been left as it should be by the persons who share the table with you. If anything is wrong, report the fact *at once* to the instructor.

When you leave, see that the water and the gas are turned off, and that everything on your table is in good order.

LABORATORY EXERCISES.

EXPERIMENT I.

THE BUNSEN BURNER.

Apparatus. — Bunsen burner, test tube, test-tube holder (see note below).

Materials. — Matches, water.

a. Examine carefully the Bunsen burner on your desk. Take it apart, and draw a sketch of each part.

b. Put the burner together, close the holes at the base, and connect with gas supply.

To light the burner, turn on the gas and then hold a lighted match near the side of the burner and about one-half a centimeter below its mouth. Note the character of the flame; is it luminous or not? Now open the holes carefully until the luminous region has just disappeared. This is the "Bunsen" flame. For most work it should be 7 to 10 centimeters (3 to 4 inches) high. The holes of the burner should be open far enough to prevent a deposit of soot upon the object heated, but not far enough to cause the flame to make a noise.

c. Introduce quickly into the center of the Bunsen flame, one-half a centimeter above the burner, the head end of a match. Result? Is the gas in this region burning?

To heat an object effectively, place it higher up in the flame; the best place is just above the apex of the dark, inner cone of unburned gas. Locate this region.

d. Put 5 c.c. water into a test tube, and make a note of the height of the column of water in centimeters. Whenever you are asked to take 2, 5, 10, etc., cubic centimeters of anything, refer to this experiment, and use the length of the column just measured as your *unit.*

e. Heat the water in the test tube to boiling. To do this properly have the outside of the tube *dry;* hold the tube in the holder, and incline the tube at an angle of about 45° to the table top. Then introduce the bottom of the tube into the effective region (cf. *c*) of the flame. *Heat only the part of the tube containing the liquid;* if the flame strikes the glass above the liquid level, the tube may crack.

Do not hold the tube still, but move it gently in the flame. When boiling begins, raise the tube a little above the flame,— always keeping it inclined, — so that the water may not "boil over."

f. These directions are general, and will apply whenever you heat liquids in test tubes.

Note. — A very convenient test-tube holder can be made by folding a piece of writing paper twice, so as to produce a strip about 1 cm. wide and 10 to 15 cm. long. This is placed about the tube like a holder. The free ends are held together close to the tube.

EXPERIMENT II.

MANIPULATING GLASS TUBING.

Apparatus. — Bunsen burner, " wing-top " or illuminating gas burner, file, blast-lamp.

Materials. — Piece of soft glass tubing more than 15 cm. long, one of ignition tubing 18–20 cm. long.

a. Cut off a piece of glass tubing 15 cm. long. To do this, make on the tubing a file mark in a plane perpendicular to the length of the tubing; grasp the tube in both hands, and place the thumb nails together opposite the scratch. By *pushing* gently *with the thumbs* and at the same time *pulling with the hands* you will succeed in breaking the tubing so that the ends are fairly regular.

b. Round off (" fire-polish ") both ends of the 15 cm. tube by turning them about in the Bunsen flame until the edges become red hot. Let the ends cool.

c. Bend the 15 cm. tube at its middle into the form of a right angle. For this purpose use a *flat* Bunsen flame — produced by a " wing-top " attachment — or a flat illuminating flame.

Take the tube in both hands, one at each end, and hold its central part *lengthwise with* and *over* the flat flame. At the same time twirl the tube between thumbs and forefingers. Then lower the tube — keep turning it — into the upper part of the flame, and heat until you find that the glass is fairly soft. Then bend *gently* to a right angle.

d. If you used the Bunsen flame, *anneal* the glass at the bend by closing the holes of the burner and allowing

the hot glass to cool first in the *smoky* flame. When the bend is covered with soot, support it so that it will not touch a cold object. When the tube is cold, wipe off the soot.

e. Make two "ignition tubes" of hard glass by melting a piece of hard glass tubing 18–20 cm. long at its middle in the flame of a blast-lamp. Do this by grasping one end of the tubing between the thumb and forefinger of each hand, and twirling it rapidly in the flame until the glass softens and the walls of the tubing come close together. Then draw the two halves apart, but do not break the connection until the glass becomes stiff. Now break the connecting tube, and melt off the drawn-out glass where the tube becomes narrow. For this use a small blast-lamp flame. When the closed end of the ignition tube is cool, "fire-polish" the open end in the blast-lamp flame.

EXPERIMENT III.

SOLUTION, FILTRATION, AND EVAPORATION.

Apparatus. — Glass rod 15 cm. long (unfinished), file, two beakers of about 50 c.c. capacity, ring stand, wire gauze, funnel, funnel support (small ring of ring stand), evaporating dish, test tubes, mortar.

Materials. — Marble, salt, dilute hydrochloric acid, filter paper.

a. Make a glass stirring rod 15 cm. long, cutting off a piece from a larger one, just as in Experiment II, *a*. Round off both ends in the flame.

Taste a bit of marble, then put it into a test tube and add a drop of dilute hydrochloric acid. Results? Do the same with a pinch of salt, and state results. How can you distinguish marble from salt?

b. In a mortar powder a lump of marble, add to it about $\frac{1}{6}$ of a test tube of salt, and grind the two thoroughly together. Put the mixture into a beaker with about 20 c.c. cold water, and heat the beaker over the flame until its contents boil. Before heating the beaker see that it is *dry* on the outside, then place it upon a wire gauze supported on the ring stand. Move the flame about under the gauze until the beaker has become *warm;* then put the burner under the center of the beaker. The height of the gauze above the burner should be so great that the bottom of the beaker may be a little above the apex of the dark inner region of the flame.

Note. — *Always follow these directions* when you are heating a beaker, an evaporating dish, or a flask, unless there is some special reason for not doing so. What becomes of the salt? Of the marble?

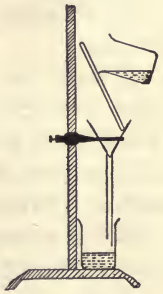

FIG. 93.

c. Next, *filter* the solution. You need a funnel, a support (see above), a filter, the glass rod made in *a*, and a second beaker.

Fold the circular filter twice in lines at right angles to each other. Press the folded edges between thumb and forefinger, but *not* between the nails. Open the filter so that it shall form an inverted cone which just *fits* the funnel. One-half of the conical surface is made up of three of the quarters into

which the paper was folded; the remaining quarter of the paper makes up the other half of the cone.

d. Hold the filter in place in the funnel, and wet it completely; it should adhere everywhere to the inner surface of the funnel, and its point should extend a little into the stem of the funnel.

Pour the salt solution down the glass rod to the filter. The glass rod should touch the lip of the beaker; and the stem of the funnel should touch the side of the beaker beneath it.

Always follow these directions in filtering an insoluble solid from a solution.

e. Does anything remain on the filter? We call it the *residue.* What passes through is the *filtrate.* Test the residue as you did the marble and salt in *a.* What is it?

A substance which remains *mixed* with a liquid, but not dissolved in it, is said to be "suspended in," or "held in suspension by" the liquid.

A *suspended* substance becomes, after filtration, a *residue.*

f. Pour the filtrate of *c* into an evaporating dish, and heat (for precautions, cf. *b*) over the flame. Boil off the water until a solid begins to separate out; then set the dish aside until it is cold, or until the next laboratory period. What is the solid obtained?

Is this separation of the salt from the marble a physical or a chemical operation?

EXPERIMENT IV.

EFFECT OF HEAT UPON OXIDES.

Apparatus. — Small ignition tube of hard glass, rubber connecting tube, delivery tube, pneumatic trough, test tube, ring stand, clamp.

Materials. — Pine splinter, mercuric oxide, lead dioxide.

a. In a small tube of hard glass sealed at one end and about 10 cm. long — " ignition tube " — place a layer of mercuric oxide *not more than* one-half a centimeter thick.

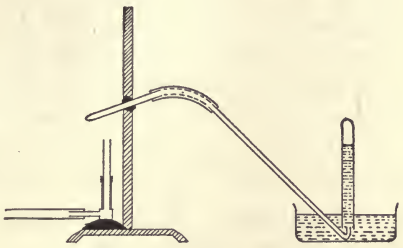

FIG. 94.

In a basin containing water, invert a test tube of water. See that no air bubbles remain in the test tube. Vessels for holding water over which gases are collected are called " pneumatic troughs."

Attach to the ignition tube by means of a piece of rubber tubing a delivery tube long enough to reach to the bottom of the pneumatic trough. Support the ignition and delivery tubes so that the closed end of the ignition tube is only a little lower than its other end, and so that the mercuric oxide may be heated in the hot portion of the Bunsen flame.

b. Begin to heat slowly, keeping the flame in motion. Note any change in color of the oxide. Afterward heat

strongly with a steady flame until all of the powder disappears. Collect *over water* anything that escapes from the delivery tube by allowing it to displace the water of the test tube. When the operation is over, *remove the delivery tube from the water before removing the flame.* Why?

c. Cover the mouth of the test tube under water with the thumb, remove tube from water, invert, and introduce a pine splinter with a *spark* on the end of it. Result? Is the gas in the test tube *air?* What is it?

d. When the ignition tube is cool, invert it and strike its open end sharply against the table. Result? What substance is this? On what part of the tube did it collect? Why did it not pass out of the tube?

e. Would you call this a chemical change, or not? How is mercurie oxide made? Consult a text.

f. Repeat *a*, *b*, *c*, and *d*, using **lead dioxide** instead of mercuric oxide. Does the powder disappear? Does it give off a gas? What is the gas? What is the residue? Answer *e* for this case also.

EXPERIMENT V.

OXYGEN.

Apparatus. — Mortar and pestle (?), test tubes, ring stand and clamp, one-holed stopper, delivery tube, pneumatic trough, 4 collecting bottles, glass or cardboard cover, deflagration spoon.

Materials. — Powdered potassium chlorate and manganese dioxide, pine splinter, sulphur, iron wire (picture cord) at least 15 cm. long, lime-water, magnesium wire or ribbon.

a. On a *clean* piece of writing paper mix carefully 6–8 c.c. powdered potassium chlorate with about 3 c.c. powdered manganese dioxide. If the substances are not found in powdered form in the laboratory, grind them *separately*, in *clean* mortars, before mixing.

b. Before you use the whole mixture, test the quality of a sample (1 c.c.) by heating it gently in an *open* test tube. If there is any evidence of *violent combustion*, or if *large* sparks appear, reject the mixture, and make a fresh one. A few *small* sparks indicate only traces of dust, etc.

c. If the mixture is satisfactory, put it into a test tube supported by a clamp attached to a ring stand. The test tube is then fitted with a one-holed stopper and a delivery tube reaching under water in a pneumatic trough.

Have 4 bottles filled with water and inverted in the trough.

To invert bottles in the trough without letting in air, fill them to overflowing with water, cover their mouths with slips of glass or cardboard, press the latter against the bottle, and invert quickly under water. Then remove the covers.

To remove a bottle full of gas from water, slip under the mouth of the bottle, *under water*, a glass or cardboard cover, and hold it in place as before. Leave a filled bottle with its mouth under water until used, if possible.

Whether a bottle of gas shall be placed *upright* or *inverted* upon the table depends upon the *specific gravity* of the gas.

d. Heat the test tube *gently* from the top of the mixture *downward.* Regulate the flame so as to keep the

evolution of gas *steady, but not violent. Keep the flame in motion,* so as not to soften the glass.

When the collecting bottles are full, *first* take the delivery tube out of the water, and *then* remove the flame. Why this precaution?

The gas is **oxygen.**

e. Into one bottle of the gas put a glowing splinter as in Experiment IV, *c.* Result? Gradually lower the splinter into the bottle until combustion stops. What becomes of the splinter? Of the oxygen?

To the contents of the bottle add 5 c.c. calcium hydroxide solution (lime-water), cover with the hand, and shake vigorously. Result?

N.B. Lime-water reacts with **carbon dioxide** to give a white, insoluble solid, **calcium carbonate.** This serves as a **test** for carbon dioxide. Where does the carbon of the carbon dioxide come from?

f. Note the odor of the gas in the second bottle. Then put into the bottle a deflagrating spoon containing burning sulphur. Light the sulphur by holding the spoon in a flame.

Have a cardboard cover with a small hole for the handle of the deflagrating spoon, and keep the bottle covered until combustion stops. Results?

What becomes of the sulphur? Of the oxygen? Note the odor of the gas now in the bottle. Does this gas support the combustion of a splinter? Try it. Name the gas. Add 5 c.c. of water to the bottle, shake it about, and then put in one piece each of red and blue litmus paper. Result?

g. Have the third bottle of oxygen covered and set upright on the table. Draw aside the cover for a moment

while you pour in sand enough to cover the bottom of the bottle; then replace the cover.

Melt some sulphur in a deflagrating spoon, and dip into it one end of a piece of iron picture cord. Light the sulphur tip, and *at once* hold the iron wire in the bottle of oxygen. Result? Keep the wire in the gas until action ceases. Describe the product and name it. Why was the iron tipped with sulphur?

h. Hold a piece of magnesium wire or ribbon by means of iron tongs, or make a hook upon it, and hang it on the reverse end of a file. Light it in the Bunsen flame, and hold it in the fourth bottle of oxygen. Result? Name and describe the product. Add a few drops (not more) of water to the product in the bottle, and then bring into contact with it one piece each of red and blue litmus paper. Let them remain some time. Which one is changed? Compare with the result in *f*.

EXPERIMENT VI.

PER CENT OF OXYGEN IN POTASSIUM CHLORATE.

Apparatus. — Hard glass test tube, Bunsen burner, clamp, and ring stand.

Materials. — Pure, powdered potassium chlorate which has been dried in an air bath at 120° C.

a. The **object of this experiment** is given in the title. It is attained by decomposing completely a weighed amount of pure, dry potassium chlorate and weighing the potassium **chloride** that remains. The material lost is *oxygen*.

b. Weigh a clean, dry hard-glass test tube accurately,

and put into it about 5 c.c. (a layer 1 inch thick) of the potassium chlorate. Wipe off any particles that may adhere to the mouth of the test tube. Weigh the test tube and chlorate accurately, and record the weights as directed in § *d*.

c. Support the test tube of *b* by means of a clamp and a ring stand, keeping the open end of the test tube a little higher than the closed one. Have the clamp near the **open** end. Begin to apply heat *cautiously*, with a small, moving flame. Then heat more strongly, until all the chlorate melts, and the melted substance is in effervescence. Do not let the effervescence become so rapid that *much* white smoke is driven out of the test tube. When all effervescence seems to have stopped, heat more strongly still, so that every part of the contents is completely melted and ceases to effervesce. Then let the tube cool, weigh it, and record the result. To make certain that the decomposition is complete, heat the tube again, cautiously at first, then strongly, and weigh the tube once more. Continue this until there is no difference between successive weighings. We call this **"heating to constant weight."** Use the **last** weight in calculating results.

d. Record the results as follows: —

		Grams.
Wt. of test tube + potassium chlorate	=	
„ „ „ „ alone	=	
„ „ potassium chlorate taken	=	
Wt. of test tube + potassium chlorate	=	
„ „ „ „ + „ chloride	=	
∴ The wt. of oxygen evolved	=	.
Per cent of oxygen =		

EXPERIMENT VII.

KINDLING TEMPERATURE.

Apparatus. — Wire gauze at least 15 cm. square, Bunsen burner, tongs.

Material. — Matches.

a. Hold the wire gauze, by means of your tongs, 7 cm. *above* the Bunsen burner. Have the holes of the burner *open* as for the Bunsen flame. Now turn on the gas and bring a burning match *from above* down to the center of the gauze. Result?

Why does not the gas *below* the gauze take fire? Is there gas below the gauze? Prove it.

b. Let the gauze cool; and then bring it down upon the Bunsen flame until the gauze is 6 to 7 cm. above the top of the burner. Result? Hold the gauze in place until it becomes red hot. Result? Explain.

EXPERIMENT VIII.

HYDROGEN.

Apparatus. — Generating flask, or bottle of 250 c.c. capacity, two-holed stopper, funnel tube, right-angled tube, rubber connector, delivery tube, pneumatic trough, squares of glass or of cardboard, two or more wide-mouth collecting bottles (250 c.c.).

Materials. — Zinc, dilute sulphuric acid (one part by volume of acid to four volumes of water), pine splinter, cupric sulphate solution.

a. To a 250 c.c. bottle containing enough zinc to cover the bottom fit a two-holed stopper. One of the holes is for a funnel tube reaching to within one-half a centimeter of the bottom of the bottle when the stopper is in place; the other hole contains a bent tube attached by a rubber connector to a delivery tube. The delivery tube reaches to a pneumatic trough containing two bottles filled with water and inverted.

b. **Caution. — Keep all flames at least one meter (about three feet) away from apparatus in which hydrogen is made.**

c. See that the stopper of the generating bottle is *tight*, and add enough of the dilute sulphuric acid to immerse the lower end of the funnel tube.

Tell what takes place in bottle, funnel tube, and pneumatic trough. Explain each phenomenon. If action is not vigorous add a few drops of copper sulphate solution. Result? If evolution of gas ceases or becomes slow before you are through, add more acid. The gas produced is *hydrogen*.

d. Fill the two bottles with the gas and refill them after using. Reject the first bottleful collected by turning it mouth upward. Why not use it? Why turn it mouth upward?

Keep the second bottle inverted and introduce into its middle part a burning pine splinter 15 to 20 cm. long. Hold the splinter steady 20 to 30 seconds. Result? Does the gas burn? Where? Does the splinter continue to burn in the hydrogen? Is hydrogen combustible or a supporter of combustion?

Turn a third bottle of the gas mouth upward one minute, and repeat the test with the burning splinter.

Results? From the result compare the specific gravity of hydrogen with that of air.

e. Place the mouth of a fourth bottle of gas over the mouth of an upright bottle of air. Hold the bottles together and reverse their positions. After one minute apply a lighted match to the lower bottle. Result? To the upper. Result? What conclusion as to the diffusibility of hydrogen?

f. Have a fifth (and last) bottle only half full of gas; incline it, and then raise it slowly from the water so that air displaces the remaining water. Carry bottle, mouth down, to a flame. Result? Explain difference between this result and the combustion of hydrogen free from air.

g. From the experiment tell whether hydrogen is very soluble in water, or not.

h. Pour the liquid and the unused zinc from the bottle into a beaker. If the zinc has all dissolved, or if there seems to be enough acid to dissolve all of it, add more zinc. Leave until action ceases.

i. Examine the beaker; has anything separated from solution? If so, re-dissolve it by heating the beaker on the wire gauze, and filter hot. (*Care!*)

Collect the filtrate in another beaker or an evaporating dish, and let it stand some hours. Result?

The substance you obtain is crystallized *zinc sulphate.*

EXPERIMENT IX.

BURNING OF HYDROGEN AND REDUCTION OF OXIDES.

Apparatus. — Hydrogen generating bottle of Experiment VIII, two-hole stopper, funnel tube, right-angle tube, rubber connector, a second right-angle tube of slightly larger diameter than the other, beaker, and test tube.

Materials. — Zinc, dilute sulphuric acid, cupric sulphate solution, cupric oxide (in wire form if possible).

a. Arrange the apparatus of Fig. 95. Into the longer (horizontal) arm of the second right-angle tube (*B*) put cupric oxide in wire form. To the zinc in the generating bottle (*A*) add a few drops of cupric sulphate solution, then dilute sulphuric acid. When the gas comes off readily, hold over the end of the exit tube (*C*) a cold, clean beaker. Does any deposit of moisture appear?

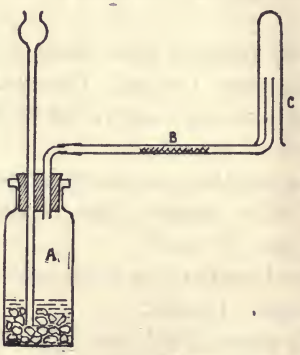

FIG. 95.

b. Over the end of *C* invert a test tube, and after a minute carry it, mouth down, to a flame at least 4 feet away. Note what happens, and *at once* return the test tube, still mouth down, to the jet *C*. Continue until the hydrogen is lighted at *C* (consult § 50, pg. 41, of text). What is the color of the hydrogen flame *at first?*

After the end of *C* has become hot? For the reason, *cf.* § 411 of text. Hold a cold beaker over the hydrogen flame. Is there a deposit now? What is it? How was it formed?

c. While the hydrogen flame is burning, heat the tube at *B*, under the cupric oxide, first with a moving flame, then more strongly. Do not heat it enough to melt the glass.

What change occurs in the cupric oxide? What is the solid substance left? Is there any deposit in the tube? What is it? What was the source of the oxygen when hydrogen **burned?** When it was passed over cupric oxide? Define **reduction.**

EXPERIMENT X.

EQUIVALENT WEIGHT OF MAGNESIUM.

Apparatus. — Balances, pneumatic trough, wide-mouth bottle (250 c.c.), graduated jar, glass or cardboard cover.

Materials. — Magnesium wire, dilute sulphuric acid.

a. The **object of this experiment** is to find how many grams of magnesium replace **1.008** grams of hydrogen. The resulting number is called the **equivalent weight** of magnesium. The weight of the hydrogen is calculated from the volume. The volume actually obtained is "reduced" to 0° C. and 760 mm. From this we get the weight, for 1 l. of hydrogen at 0° C. and 760 mm. weighs 0.09 gram (*cf.* Appendix v).

b. In a pneumatic trough containing water to the

depth of about 3 cm. place a piece of magnesium wire the exact weight of which is known. There should be not more than 0.2 gram.

Get the exact capacity in cubic centimeters of a wide-mouth bottle by *filling* it with water and pouring the water into a graduated vessel. The bottle should hold at least 250 c.c.

c. Half fill the bottle with dilute sulphuric acid, then add enough water to fill it, and invert it in the pneumatic trough as far from the magnesium as possible. See that the bottle is free from air bubbles. Now slide the mouth of the bottle, under water, over the magnesium. Result?

d. When all the metal has disappeared, let the collected gas cool to room temperature for 5 minutes. Then add water of room temperature to the bowl, *if necessary*, so that the level of water in bottle and bowl shall be the same. Why?

Protect the bottle from the heat of the hand by grasping it with a towel; then slip under its mouth a glass or cardboard cover, and invert *quickly*, so as to lose none of the water in the bottle.

Bring a flame to the mouth of the bottle *at once.* Result?

The gas is *hydrogen.* The other product of the reaction is magnesium sulphate; it remains in solution.

Let your thermometer remain in the solution in the bottle for five minutes; then read it, and call this the **temperature** of the hydrogen. Also read the **barometer.**

e. Get the volume of the water remaining in the bottle by means of a graduated vessel. Then obtain the volume of the hydrogen *by difference.* From the reading

of the barometer, *in millimeters*, subtract the "tension of water vapor," to get the partial pressure of the **dry** hydrogen, and then reduce the volume of the hydrogen to standard conditions.

f. Calculate the **weight** of the hydrogen, and solve the following proportion for x, the **equivalent weight** of magnesium.

Wt. of magnesium : Wt. of hydrogen :: x : 1.008.

g. **Record your results** as follows: —

Wt. of magnesium taken	=	g.
Vol. of hydrogen obtained	=	c.c.
Temperature	=	° C.
Barometer reading	=	mm.
Tension of water vapor at ° C.	=	mm.
∴ Partial pressure of dry gas	=	mm.
Vol. of dry hydrogen at 0° C. and 760 mm.	=	c.c.
Wt. of dry hydrogen	=	g.

Equivalent weight of magnesium =

EXPERIMENT XI.

PHYSICAL PROPERTIES OF WATER.

Apparatus. — Ring stand, wire gauze, 100 c.c. flask, one-hole cork stopper, doubly bent delivery tube, test tube, beaker, Bunsen burner, thermometer, evaporating dish.

Materials. — Hydrant or well water, distilled water, salt, crushed or chipped ice.

a. **Distillation of Water.** Set up the apparatus of Fig. 96. Half fill the flask with hydrant water, support it on the wire gauze, and attach the doubly bent delivery tube. This reaches to a test tube standing in a beaker (or bottle) of cold water. The test tube serves as both condenser and receiver. Distill the water until the *distillate* half fills the test tube. Taste the distilled water. Evaporate 5 c.c. of it to dryness in a **clean** evaporating dish. Note if there is a residue, and its amount. For comparison, evaporate 5 c.c. of hydrant water to dryness, and give the result. Define *distillation.*

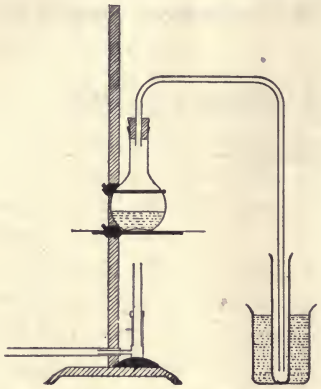

FIG. 96.

b. **Boiling Point of Water.** Support a flask securely (use clamp or extra ring) on the wire gauze of a ring stand, fill it one third with distilled water, and boil the water. Get the temperature of the boiling water by immersing the bulb of the thermometer in it. Do not read the temperature until it is constant. The bulb must be **completely** immersed. Now wipe the bulb of the thermometer **dry,** and hold the bulb in the escaping steam about 2–3 cm. above the level of the water. Compare the two temperatures, and write them down.

Add more distilled water, if necessary, and one-third of a test tube of **salt.** Boil the salt water, and get its temperature. Also wipe the bulb of the thermometer

perfectly clean and dry, and get the temperature of the escaping steam. Give the results.

c. **Melting Point of Ice; a Freezing Mixture.** — Into a 50 c.c. beaker put about 30 c.c. of crushed or chipped ice, and stir it with the bulb end of the thermometer. Have the bulb completely immersed. Give the exact reading as shown by your thermometer. Is your thermometer correctly graduated? Now add half a test tube of salt to the crushed ice, and stir the mixture with the thermometer. What is the temperature? Will any other substances give freezing mixtures with ice? Consult text.

EXPERIMENT XII.

CHEMICAL PROPERTIES OF WATER.

Apparatus. — Tongs or forceps, evaporating dish, small wide-mouth collecting bottle, glass square.

Materials. — Sodium, water, blue and red litmus paper, solid sodium hydroxide, quicklime, anhydrous cupric sulphate.

a. **Action of Sodium upon Water.**

Caution. — Do not handle sodium with **wet hands,** or with **wet forceps.** Do not put sodium into the waste jar. **On no account** leave any sodium on or about your desk or in your locker. Sodium is usually kept under kerosene or ligroin (*cf.* § 525 of text).

What is the appearance of a freshly cut surface of sodium? Is sodium hard or soft? Heavy or light?

Fill your smallest gas-collecting bottle three-fourths full of water, and cover it with a glass square. Draw

aside the cover, drop in a small piece of sodium (not over 8–10 cubic millimeters in volume: size of a wheat grain), and cover it **at once.** Note the action. When the sodium has disappeared, apply a lighted match to the bottle. Result? What gas is formed when sodium reacts with water? Test the solution by rubbing it between the fingers. Result? If you get no decided effect, add a second piece of sodium (**dry hands**) exactly as you did the first, and repeat the test.

Put one piece each of red and blue litmus paper into the solution, and give the results. Compare with Experiment V, §§ *f* and *h*.

b. Add a small piece (same size as sodium used) of sodium hydroxide to 5 c.c. of water. Test the resulting solution with the fingers and with litmus, and compare the effects with those of *a*. Conclusion?

c. **Action of Water with Quicklime.** — In an evaporating dish treat a lump of quicklime about the size of a small hickory nut, or a large cherry, with water, as long as the water is **completely** absorbed. Do not have an excess of water. Note the result after a few minutes. If no result appears, try the effect of warming the dish slightly. If there is still no result, repeat the experiment with a second lump of quicklime. Use the quicklime prepared from marble, if possible.

How is commercial quicklime made? Of what elements is it composed? What change takes place in slaking it? For what is it used? Consult text for answers.

d. **Action of Water with Anhydrous Cupric Sulphate.** — Compare the colors of blue vitriol and anhydrous cupric sulphate. To about 1 c.c. of anhydrous cupric sulphate

held in the palm of your hand add one or two drops of water. What two results do you notice? What is the difference, as shown by this experiment, between blue vitriol and cupric sulphate?

EXPERIMENT XIII.

EQUIVALENT WEIGHTS OF MAGNESIUM AND OXYGEN.

Apparatus. — Evaporating dish, watch glass, evaporating apparatus (*cf. b*), tongs.

Materials. — Magnesium wire or ribbon, dilute nitric acid.

a. **The object of this experiment** is to determine the number of grams of magnesium that combine with 8 grams of oxygen. **The method used** is to convert the magnesium into *magnesium nitrate* (*cf.* § 227 of text), and then to decompose the magnesium nitrate by heat (*cf.* § 230 of text). The residue is *magnesium oxide.*

In a weighed porcelain evaporating dish weigh out accurately about 0.5 g. of magnesium wire or ribbon. Provide the evaporating dish with a watch glass cover to prevent spattering. Draw this aside slightly, and add dilute nitric acid, a few drops at a time, until the metal has dissolved. Rinse the under side of the watch glass with 10 c.c. of water, collecting the rinsings in the evaporating dish. Remove the watch glass cover when evaporating in *b*.

b. Evaporate the solution of magnesium nitrate (on a water bath or steam bath if possible; otherwise on a wire gauze) until the residue is syrupy. Be careful to

avoid loss. Further evaporation *over* a flame generally causes spattering; but the heating may be continued safely if the flame is applied from above. Do this as follows: —

Hold the evaporating dish by means of iron or brass tongs grasped in the left hand, and carefully move the dish about, so that the syrupy liquid is spread in a thin layer over the sides of the dish, but not nearer to the edge than *one centimeter*. At the same time hold the Bunsen burner in the right hand, move the flame gently round and round, and direct it upon the contents of the dish. By careful manipulation the magnesium oxide may be obtained as an opaque powder. When the decomposition of the nitrate seems complete, apply the flame from below again. Heat the dish to faint redness for five minutes, cool it, and get its weight. Record your weights as in Experiment VI.

To make sure that the dish is at **constant weight,** heat it carefully once more to redness, let it cool, and weigh it. If there is a loss, repeat the heating. Record the final weight.

c. Get the weight of the oxygen that combined with the magnesium. Then solve the following proportion for x: —

Wt. of magnesium : wt. of oxygen :: x : **8.**

Compare the **equivalent** of magnesium thus obtained with that obtained in Experiment X. What is the correct amount? What quantities of hydrogen and of oxygen are equivalent to this weight of magnesium? In what proportion, by weight, are they combined in water?

EXPERIMENT XIV.

SOLUTION AND CRYSTALLIZATION.

Apparatus. — Beaker (50 c.c.), stirring rod.

Materials. — Potash alum, crystallized cupric sulphate (blue vitriol).

a. Put 20 c.c. water into a beaker, add 10 grams powdered alum, and stir two minutes with the stirring rod. Does all the alum dissolve?

b. Heat the beaker carefully on the wire gauze, stirring the contents. Result? Conclusion.

c. Set the beaker with the hot solution in cold water, and stir rapidly until solution cools. Result?

d. Dry the outside of the beaker, and heat again as in *b.* Result? Let the solution stand undisturbed until it is cold. Result? Compare with *c,* and account for the difference.

e. Repeat *a, b, c,* and *d,* with 20 c.c. water and 15 grams powdered blue vitriol. Results?

EXPERIMENT XV.

PRECIPITATION.

Apparatus. — Test tubes.

Materials. — Solutions of lead nitrate, potassium chromate, barium chloride, and calcium sulphate. Dilute sulphuric acid; alcohol.

a. To 5 c.c. of lead nitrate solution in a test tube add an equal volume of potassium chromate solution. Result? Let tube stand ten to fifteen minutes. Result? The precipitate is *lead chromate.*

b. Repeat *a,* putting together hot barium chloride solution and dilute sulphuric acid. Result after ten to fifteen minutes? The precipitate is *barium sulphate.*

c. To 2 c.c. calcium sulphate solution add an equal volume of alcohol. Result? The precipitate is *calcium sulphate.*

Note. — The insoluble solids formed in *a* and *b* are not the only products of these reactions; the other products are, however, soluble.

EXPERIMENT XVI.

SOLUBILITY OF POTASSIUM CHLORIDE.

Apparatus. — Steam bath, water bath, or wire gauze; evaporating dish, balances.

Materials. — Powdered potassium chloride, distilled water.

a. Make a saturated solution of potassium chloride by shaking 12 grams of the powdered substance in a clean flask with 25 c.c. distilled water at the temperature of the room. Continue shaking every little while for fifteen minutes. Record the temperature of the solution, and then weigh out *accurately* into your evaporating dish about 20 grams of the solution. Now evaporate (see *b*) the water until the residual potassium chloride is perfectly dry, and get its weight. From the results

calculate how much potassium chloride will dissolve in 100 grams of water at the room temperature.

b. If possible, evaporate the solution of *a* on a steam or water bath. If this is impossible, evaporate slowly and carefully on wire gauze, so as to avoid any loss by spattering.

c. Record your results thus: —

	Grams.
Wt. of evaporating dish + water + KCl	=
" " " " alone	=
∴ Wt. of water + KCl	=
Wt. of evaporating dish + KCl	=
" " " " alone	=
∴ Wt. of KCl	=

∴ Wt. of water found : Wt. KCl found :: 100 grams : x.

EXPERIMENT XVII.

WATER OF CRYSTALLIZATION.

Apparatus. — Test tubes, iron saucer (sand bath).

Materials. — Crystals of zinc sulphate, of potash alum (potassium aluminum sulphate), and of cupric sulphate.

a. Place a few crystals of zinc sulphate in a *dry* test tube, and warm *gently*. Results? Is there evidence of water? Where?

b. Repeat *a*, using a crystal of potash alum. Results?

c. Note the taste of another crystal of potash alum; then heat it *strongly* in an iron dish until no further change occurs. Results?

When the ignited alum is *cold*, taste it. Result? Place it in 5 c.c. water in a test tube, and boil carefully for five minutes. When the water is cool, taste it. Result?

Assuming that heat simply drove off crystal-water from the alum, upon what does the taste of crystalline alum seem to depend?

d. Heat a crystal of copper sulphate (blue vitriol) strongly in an iron dish. Result? When the residue is cold, add a few drops of water to it. Result? Explain.

EXPERIMENT XVIII.

EFFLORESCENCE AND DELIQUESCENCE.

Apparatus. — Evaporating dish, beaker, watch glass.

Materials. — Hydrates of sodium carbonate (washing soda) and of sodium sulphate (Glauber's salt), solid potassium hydroxide, anhydrous calcium chloride.

a. Expose a bright crystal of washing soda to the air for at least twenty-four hours. Result?

b. Carefully weigh your evaporating dish, and then weigh into it *accurately* about 5 g. of bright crystals of Glauber's salt (hydrate of sodium sulphate). Leave the dish uncovered for at least twenty-four hours, and weigh dish and contents. Result? Continue weighing at intervals until there is no further loss. Calculate the per cent of loss. What is it that escapes? Record your results systematically, as in Experiment VI.

c. In a small beaker place a piece of potassium hydroxide, and leave it exposed to the air at least an hour. Result?

d. Weigh an evaporating dish or a watch glass carefully, and then weigh into it *accurately* about 5 grams anhydrous calcium chloride. Let stand at least twenty-four hours, and weigh again. Results? Record the weighings as in *b*. What do these substances absorb from the air?

EXPERIMENT XIX.

PER CENT OF WATER OF CRYSTALLIZATION.

Apparatus. — Evaporating dish, balances, wire gauze, ring stand.

Materials. — Powdered gypsum (*not* plaster of Paris), chemically pure barium chloride (the hydrate).

a. Weigh your evaporating dish (be sure it is clean and dry), and into it weigh *accurately* about 3 grams of finely powdered gypsum. Get the exact weight of the gypsum taken, and record it.

b. Heat the evaporating dish on a clean wire gauze for ten minutes with the hottest Bunsen flame. Then let the dish cool, weigh it, and record the result. Now heat the dish again for five minutes, let it cool, and determine the weight. Continue until you have "constant weight."

c. Record your results thus:—

	Grams.
Wt. of evaporating dish + gypsum	=
" " " " alone	=
∴ Wt. of gypsum taken	=
Wt. of evaporating dish + calcium sulphate	=
" " " " alone	=
∴ Weight of water found	=
∴ Per cent of water in gypsum	=

d. Weigh into the evaporating dish, accurately, about 3 grams of pure, powdered barium chloride. Place the evaporating dish on a wire gauze about 4 inches (1 dm.) above the top of a Bunsen flame. Heat the dish for ten minutes, then let it cool, and weigh it. Heat it again, to constant weight. Record the results as in *c*, and calculate the per cent of water driven off.

EXPERIMENT XX.

DEFINITE PROPORTIONS.

Apparatus. — Evaporating dishes, beaker, balances, watch glass.

Materials. — Sodium bicarbonate, dilute hydrochloric acid.

a. Weigh your evaporating dish carefully, and then weigh into it *accurately* about 5 grams of sodium bicarbonate. Transfer the bicarbonate *without loss* to a beaker covered with a watch glass; then add the dilute hydrochloric acid a little at a time. When adding acid draw the watch glass a little to one side; at other times let it cover the beaker.

b. The *effervescence* (foaming) is due to the escape of carbon dioxide gas. When all the solid has dissolved, add a drop or two more of the acid, to be sure no bicarbonate remains; then pour the solution into the weighed evaporating dish. With 5 c.c. water, wash what has spattered on the watch glass into the beaker, and with this water rinse what adheres to the beaker into the evaporating dish. Rinse the beaker with 5 c.c. more water, and add the rinsings to the evaporating dish.

c. Evaporate the solution to *dryness*, on a water bath or a steam bath, if possible; otherwise, on a wire gauze. If you use wire gauze take great care to avoid spattering either the solution or the solid which remains after the water has boiled away. If considerable spattering begins, remove the flame for a moment and let the dish cool; then apply the flame again *gently*. *Keep flame in constant motion at the end of the process.*

When the solid in the dish is perfectly dry, let the dish cool to the temperature of the room. Then weigh it *accurately*. Heat to constant weight.

d. Record your results thus: —

	Grams.
Wt. of evaporating dish + sodium bicarbonate =	
" " " " alone =	
∴ Wt. of bicarbonate used =	
Wt. of evaporating dish + sodium chloride =	
" " " " alone =	
∴ Wt. of sodium chloride formed =	

Get the simplest ratio between the amount of bicarbonate taken and that of sodium chloride obtained as follows: —

Wt. of bicarbonate : Wt. of sodium chloride :: 1 : x.

Calculate the value of x to two decimal places. $x = ?$

e. Repeat the preceding operations, weighing out *accurately* about 8 grams sodium bicarbonate. If the volume of the solution is too great to go into the evaporating dish *all at once*, evaporate part of the water and then add the remainder of the solution. *Be sure to rinse.*

Calculate the ratio between sodium bicarbonate and sodium chloride as before. Compare the ratios. Conclusion?

EXPERIMENT XXI.

CHLORINE.

Caution. — *Avoid inhaling much chlorine.* If you have inhaled it, smell ammonia cautiously. If the gas gets into the room, sprinkle a few drops of ammonia water upon your table.

Apparatus. — 100 c.c. flask, ring stand, wire gauze, one-holed stopper, two right-angled tubes (one with long arm), rubber connector, collecting bottle, test tubes, perforated cardboard cover.

Materials. — Manganese dioxide (in lumps), concentrated hydrochloric acid, white paper, red cheese cloth, litmus solution, indigo solution, potassium chlorate, ink, printed paper.

a. Support a 100 c.c. flask on a wire gauze in a ring stand. The flask is provided with a one-holed stopper and a delivery tube bent twice at right angles. The double bend is produced by joining two right-angle tubes by means of a rubber connector. The second right-angle tube is turned down; its end should be 2 to 3 cm. above the table.

b. Put into the flask half a test tube of manganese dioxide in small lumps, add 20 c.c. concentrated hydrochloric acid, and attach stopper and delivery tube.

Warm the flask *gently*, and fill a dry bottle, turned mouth up, with the resulting *chlorine* gas. While the bottle is being filled keep it covered with a piece of card-

board; the cardboard has a hole for the delivery tube. You may know when the bottle is full by the rise of chlorine to the top; white paper held behind the bottle will help you.

c. Stopper the bottle when it is full, and fill two dry test tubes with the gas. Then pass the gas for five minutes into 15 c.c. *cold* water in a test tube. This gives *chlorine water.*

When you are through, disconnect the apparatus *at once,* and wash the remaining manganese dioxide twice with water.

d. What is the color of the gas? Apply a lighted match to a test tube of it. Does the gas burn? Support combustion?

e. Put into the bottle of the gas a small piece (2 cm. square) of *dry* red cheese cloth, a *wet* piece of the same, a piece of paper containing print, and a paper with ink marks. Leave ten to fifteen minutes. Results?

f. Put 5 c.c. of the solution of chlorine made in *c* upon 1 sq. cm. of the colored cloth in a test tube. Upon paper with both print and ink marks on it. Results? What seems to be necessary in order that chlorine may bleach?

g. Into a test tube of the gas pour 5 c.c. cold water, close the mouth of the test tube tightly with the thumb, and shake *vigorously.* Remove thumb under water. Result? Explain.

h. To 1 c.c. dilute litmus solution, add chlorine water until you get a decided change. Explain result. Repeat, using indigo solution instead of litmus. Result?

i. An easy way to make a solution of chlorine is to treat about 1 gram of potassium chlorate with 5 c.c.

concentrated hydrochloric acid. If action is *slow*, warm *gently*. When the effervescence is rapid, add 10 c.c. cold water.

EXPERIMENT XXII.

HYDROGEN CHLORIDE.

Apparatus. — Same as in Experiment XXI.

Materials. — Sodium chloride, concentrated sulphuric acid, red and blue litmus paper, iron filings, silver nitrate solution, ammonium hydroxide solution, dilute hydrochloric acid, sodium chloride solution, calcium chloride solution.

a. Into a 100 c.c. flask with stopper and delivery tube as in Experiment XXI, put 5 to 7 c.c. water, and add *carefully* 20 c.c. concentrated sulphuric acid. Result?

Caution. — In diluting sulphuric acid always pour the acid *into the water*.

b. Cool the diluted acid by holding the flask in a stream of running water. When the acid is cold, put into it about 15 grams sodium chloride.

c. Attach the stopper and the delivery tube, and place the flask on the wire gauze of a ring stand. Warm carefully with a small flame, and fill a *dry* bottle with the gas, — it is *hydrogen chloride*, — as in Experiment XXI, *b*.

You may know that the bottle is full when white fumes escape about the cardboard which covers the collecting bottle.

Fill, also, a dry test tube, and stopper both vessels.

d. Test the gas at the end of the delivery tube with strips of moistened red and blue litmus paper. Results?

Blow your breath against the stream of gas. Result? Explain.

e. Now let the end of the delivery tube come *just to the surface* of 5 c.c. water in a test tube. Note the appearance of the water below the delivery tube. While the gas is coming off regularly, raise the test tube so that the end of the delivery tube is about 2 cm. below the water level. Do gas bubbles pass *through* the water? Why? Lower the test tube again until the delivery tube is at the surface, and let the gas run into the water five minutes. Is there any change in temperature?

Finally remove the delivery tube from the water and extinguish the flame. Save the liquid.

Lower the wire gauze so as to let the flask cool out of contact with the gauze.

f. Open the test tube of gas under water. Result? Explain.

g. Hold a burning match in the bottle of gas. Does the gas burn? Does it support combustion?

h. Test the liquid obtained in *e* with red and blue litmus. Compare results with those given by the gas. Add a drop of the liquid to 2 c.c. water, and taste a drop held on a stirring rod. Result?

i. Pour some of the liquid of *e* upon 1 c.c. iron filings in a test tube. Result? Does the gas burn?

The equation is: $Fe+2HCl \longrightarrow FeCl_2+?$

j. Add a few drops of the liquid of *e* to 1 c.c. silver nitrate solution in a test tube. Result? The white precipitate is *silver chloride,* AgCl.

The equation is:

$$\underset{\text{silver nitrate}}{AgNO_3} + \underset{\text{hydrochloric acid}}{HCl} \longrightarrow ? + ?$$

To the precipitate add an excess of ammonium hydroxide solution, close the test tube with the thumb, and shake vigorously. Result?

k. Repeat *j*, using sodium chloride solution in place of hydrochloric acid. Result? Write the equation.

l. Repeat *j* again with calcium chloride solution in place of the acid. Results? Conclusion? Equation?

m. Note the white solid which separates when the flask becomes cool. It is chiefly sodium hydrogen sulphate, $NaHSO_4$. Write the equation.

EXPERIMENT XXIII.

WEIGHT OF A LITER OF OXYGEN.

Apparatus. — Hard-glass test tube, one-liter bottle, bent glass tubes, pinch-clamp, graduated cylinder, balances, large beaker or bottle.

Materials. — Powdered, chemically pure potassium chlorate, dried at 120° C. Water at room temperature.

a. Set up the apparatus shown in Fig. 97. *A* is a hard-glass test tube that can be slipped tightly over a rubber stopper. *B* is a liter bottle fitted with a two-hole rubber stopper. The longer tube reaches *almost* to the bottom of *B*, and is connected by a rubber tube with *D*, which reaches to the bottom of *C*. The rubber tube

may be closed by the pinch-clamp *F*. Almost fill the bottle *B* with water having the temperature of the room and then fill the tubes *B*, *F*, *D*, with water by sucking at the lower end of *D*, *A* being removed. Then close the pinch-clamp.

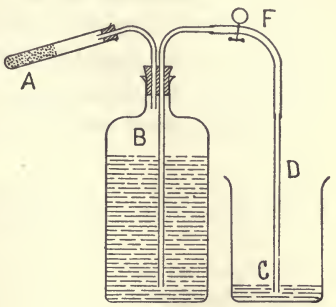

FIG. 97.

b. Into the test tube *A* put about 5 c.c. of powdered, chemically pure potassium chlorate; it must have been dried at 120° C. for at least an hour. Get the weight of test tube and chlorate *accurately* on the balances, and record it.

c. See that the stopper is pressed securely into the mouth of *B*, and then slip *A* carefully, but tightly, over its stopper. Now put about 50 c.c. water into *C*, raise *C* so that the water in *B* and *C* are at the same level, open the pinch-clamp one minute, and then close it. Then put *C* down on the table. Take *D* carefully out of *C* and get the volume of the water in *C;* then pour the water back into *C*, and put *D* in place. Now open the pinch-clamp, and hang it upon the glass tube to the left of *F*. Do not allow the lower end of *D* to get above the surface of the water in *C*. Why?

d. Heat the chlorate in *A* *gently*, beginning with a moving flame. The evolved gas forces water from *B* into *C*. When *C* is about full, stop heating, and let *A* cool to room temperature. Then raise *B* or *C*, as necessary, to make the water levels in both the same (be sure to keep the lower end of *D* under water), close the rubber

tube with the pinch-clamp, and get the volume of the water in *C*. This, *minus* the original volume, equals the volume of gas collected in *B*.

Find the barometric height, correct it for the pressure of water vapor (see Appendix), and find the temperature of the gas. Finally, weigh *A*.

e. Record your results thus: —

		Grams.
Wt. of test tube + contents at first	=	
Wt. of test tube + contents afterward	=	
∴ Wt. of oxygen	=	
Vol. of oxygen	=	*c.c.*
Temperature of oxygen	=	° C.
Barometer height (corrected)	=	*mm.*
∴ Volume of O at 0° C. and 760 mm.	=	*c.c.*
∴ Wt. of 1 l. O at 0° C. and 760 mm.	=	*g.*

EXPERIMENT XXIV.

PROPERTIES OF ACIDS.

Apparatus. — Stirring rod, test tubes or beakers.

Materials. — Nitric, sulphuric, and tartaric acids; litmus paper, phenolphthalein solution.

a. Make a very dilute solution of sulphuric acid by adding *three drops* of the concentrated acid to 10 c.c. water in a *clean* vessel. By means of a *clean* stirring rod bring a drop of this solution to the tongue. What is its taste?

Note. — Whenever you taste a substance in this way always

be sure that it is *greatly diluted.* Keep it in the mouth long enough to determine the taste *definitely;* then reject it.

b. By means of the stirring rod — it must be washed after every test — bring a drop of the dilute acid of *a* upon red and blue litmus papers. Results? A solution which turns neutral or blue litmus *red* is said to have an *acid reaction.* To the dilute acid add a drop of *phenolphthalein* solution. Result?

Note. — Litmus paper should not be wasted. One piece will do for many tests, if you use only a *drop* of the liquid each time. A new place on the litmus paper must, of course, be used at every trial. *To avoid mistakes* by reason of substances which may have spilled upon the table, lay the litmus paper upon the bottom of a *clean, inverted* beaker.

c. Try the same experiments as in *a* and *b* with nitric acid. Results? With tartaric acid. In the case of the tartaric acid use the solution obtained by heating a small crystal with 5 c.c. water. Results?

d. From Experiment XXII, *i,* tell what happens when iron is treated with hydrochloric acid. Gaseous product? Write the equation here.

From Experiment VIII tell what products are formed from zinc and dilute sulphuric acid. Write the equation.

From Experiment X tell what products are formed from magnesium and dilute sulphuric acid. If magnesium sulphate is $MgSO_4$, write the equation.

e. What seems to be the common gaseous product formed when metals act upon acids?

EXPERIMENT XXV.

PROPERTIES OF BASES.

Apparatus. — Same as in Experiment XXIV.

Materials. — Solid sodium hydroxide, potassium hydroxide, and calcium hydroxide, ammonium hydroxide solution, litmus, filter paper, phenolphthalein solution.

a. Dissolve a small piece of sodium hydroxide, NaOH, in 10 c.c. water. Rub a drop of the solution between the fingers. Result? Dilute 3 drops of this with 5 c.c. water and taste the solution, using a stirring rod. Result? Find its effect upon blue and red litmus as in Experiment XXIV, *b*. Result? Add a drop of phenolphthalein to it. Result? A solution which turns neutral or red litmus blue has an *alkaline reaction.*

b. Repeat *a*, using potassium hydroxide instead of sodium hydroxide. Results?

c. Add 2 drops of ammonium hydroxide solution, NH_4OH, to 5 c.c. water. Note taste of dilute solution and its action on blue and red litmus and phenolphthalein.

d. Treat about 1 gram calcium hydroxide, $Ca(OH)_2$, or calcium oxide, CaO, with 10 c.c. water, stir one minute, and then filter. Examine the solution — it is called *lime-water* — as to taste, feel, and action upon blue and red litmus and phenolphthalein.

EXPERIMENT XXVI.

PROPERTIES OF SALTS.

Apparatus. — Same as in Experiment XXIV.

Materials. — Sodium chloride, ammonium nitrate, potassium sulphate, sodium acetate, sodium carbonate, disodium hydrogen phosphate, phenolphthalein solution.

a. Treat about one cubic centimeter of sodium chloride, NaCl, in a test tube with 5 c.c. water. Test the solution with blue and red litmus as in Experiment XXIV, *a* and *b*. Results? Test it with phenolphthalein. Result?

b. Repeat *a* with ammonium nitrate, NH_4NO_3; with potassium sulphate, K_2SO_4; with sodium acetate, $NaC_2H_3O_2$. Results?

c. Repeat *a*, using sodium carbonate, Na_2CO_3; disodium hydrogen phosphate, Na_2HPO_4.

d. Arrange in a table the reactions of the substances you have examined with litmus in Experiments XXII, XXIV, XXV, and XXVI, thus: —

Formula of Substance.	Action upon Red Litmus.	Action upon Blue Litmus.
HCl etc.		
NaOH etc.		
NaCl etc.		

What element is found in every acid? What two elements are found in every basic hydroxide? What element is not present, usually, in the *salts*, i. e., the substances studied in this experiment?

EXPERIMENT XXVII.

NEUTRALIZATION.

Apparatus. — Evaporating dish, stirring rod, wire gauze, ring stand.

Materials. — Litmus solution and paper, sodium hydroxide solution, dilute hydrochloric and nitric acids.

a. To 5 c.c. ten per cent sodium hydroxide solution in an evaporating dish add 1 c.c. litmus solution; then add slowly dilute hydrochloric acid until the litmus changes color.

During the addition of acid, stir constantly with a glass stirring rod. If you get too much acid, add sodium hydroxide by means of the stirring rod until the color just becomes blue again; then add a *small* drop of *very dilute* hydrochloric acid. With care you can get the litmus to assume a color intermediate between the red and the blue, viz.: a decided *lavender*. This is the color of *neutral* litmus, and its formation shows that the basic properties of the sodium hydroxide solution have been *neutralized* by the hydrochloric acid.

b. Put a drop of the solution upon red litmus, as in Experiment XXIV, *b;* upon blue litmus. Result?

c. Evaporate the solution carefully. At the end, when

the water is nearly all off and spattering begins, heat with a small flame *in constant motion*.

d. Examine the product obtained in *c*, noting its taste, solubility in water, and the reaction of the solution with litmus. Results?

The substance obtained is *sodium chloride*, or common salt. Complete the equation, $NaOH + HCl \longrightarrow ? + ?$

e. Repeat *a*, *b*, *c*, and *d*, using dilute nitric acid instead of hydrochloric acid. Results?

If the product has the formula $NaNO_3$, complete the equation, —

$$NaOH + HNO_3 \longrightarrow ? + ?$$

EXPERIMENT XXVIII.

NORMAL AND ACID SALTS.

Apparatus. — Two evaporating dishes, burette, test tube, rubber band, filter paper.

Materials. — Pure concentrated sulphuric acid, ten per cent potassium hydroxide solution, phenolphthalein.

a. Put a small rubber band *evenly* around a test tube to mark off 5 c.c. (see Experiment I). Do not change the position of the rubber during the experiment.

b. Dilute 15 c.c. pure concentrated sulphuric acid by pouring it into 35 c.c. water; stir the mixture with a glass rod, and cool it as in Experiment XXII, *b*.

Hold your marked test tube vertically and pour in the dilute acid up to the mark. See that the *upper* edge of the rubber is just at the *lower* level of the *meniscus*, i. e.,

the curved surface of the liquid. Pour the 5 c.c. of acid into an evaporating dish, rinse the test tube with 5 c.c. of water, and add the rinsings to the acid in the dish.

Note what part of your evaporating dish is occupied by the resulting 10 c.c. of liquid, for comparison in *e* of this experiment. Add to the evaporating dish 3 drops of phenolphthalein solution.

c. Fill a burette with ten per cent potassium hydroxide solution. The burette is best fitted with rubber and a glass tip controlled by a pinch-clamp. If a glass stopcock is used see that it is well lubricated with vaseline. Support the burette in a clamp, put under it a beaker, and let the liquid run out until the part of the burette below the clamp is filled with liquid. Return the liquid which ran out to the burette. Read the level of the liquid *exactly* to tenths of a cubic centimeter, having your eye in the same horizontal plane with the bottom of the meniscus. Record this reading.

d. Open the clamp of the burette *carefully*, and let the potassium hydroxide solution fall *drop by drop* into the evaporating dish of dilute acid. Stir constantly. Get the solution exactly neutral, or at any rate have only one drop of alkali in excess.

Read the burette again. How much alkali was used?

e. Evaporate the solution to about 12 c.c., and let it cool thoroughly. Result?

f. Repeat *b*, *c*, and *d* with twice the quantity of dilute acid, *i. e.*, 10 c.c., and exactly as much potassium hydroxide as was used in *d*.

Test solution with litmus. Result? Evaporate the resulting solution to 5 c.c., and let it cool. Result.

g. Dry the solid substance obtained in *e* between filter

papers. What is the general shape of the crystals? Heat one in a dry test tube. Has it crystal water? Treat some of the crystals with 1 to 2 c.c. water in a test tube. Are they *easily* soluble? What is the reaction of the solution to litmus? Its taste?

h. Treat the crystals obtained in *f* as directed in *g*. Results? Are the crystals in the two cases alike?

How many salts does sulphuric acid form with potassium hydroxide, according to this experiment?

EXPERIMENT XXIX.

NORMAL AND ACID SALTS CONTINUED.

Apparatus. — Same as in Experiment XXVIII.

Materials. — Concentrated pure hydrochloric acid, ten per cent potassium hydroxide solution, phenolphthalein.

a. In the marked test tube (see Experiment XXVIII, *a*) measure out 5 c.c. concentrated hydrochloric acid, put this acid into an evaporating dish, and rinse the tube with 5 c.c. of water, as in Experiment XXVIII, *b*. Add phenolphthalein, and neutralize with ten per cent potassium hydroxide from the burette. Note the amount of alkali used.

b. Evaporate the neutral solution to dryness. Finally, heat the evaporating dish until no fumes of any kind come off, and even the *crackling* sound — *decrepitation* — practically ceases.

Let the dish cool thoroughly.

c. Examine the product, noting its solubility in water, the taste of the solution, and its reaction with litmus.

d. Repeat *a*, *b*, and *c*, with the same amount of alkali, but with twice the quantity, *i. e.*, 10 c.c., of hydrochloric acid.

Be sure to evaporate as directed in *b*.

e. Compare results with those obtained in *c*. How many salts do you get hydrochloric acid to form with potassium hydroxide?

EXPERIMENT XXX.

IONIZATION.

Apparatus. — Test tubes, mortar and pestle.

Materials. — Solutions of silver nitrate, potassium chloride, potassium chlorate, sodium hydroxide, and potassium ferrocyanide; solid ferrous sulphate, sodium bicarbonate, and tartaric acid.

a. **Double decomposition between two salts.** Review Experiment XV, *a*, and write the equation here. In the double decomposition reactions of *acids*, *bases*, *salts*, and *water*, the materials that react may be classified under the following heads:

1. **Metals,**
2. **Hydrogen,**
3. **Acid radical,**
4. **Hydroxyl.**

Classify the materials of the two salts of Experiment XV, *a*, under these heads.

Take 2 c.c. silver nitrate solution in each of two test tubes. To one add a few drops of potassium chloride solution. Write the equation, indicating the precipitate by an arrow (↓). Classify the materials that react in this case also. Why is a precipitate formed?

To the other tube of silver nitrate add some **pure** potassium chlorate solution. Result? Write the *equilibrium equation* ($\rightleftharpoons$) for the reaction. Why is there no precipitate? Of what radical is the chlorine a part?

b. **Double decomposition between salts and bases.** Powder about 1 c.c. of ferrous sulphate, $FeSO_4$, and shake it with 5 c.c. of water. Pour off the solution, and add to it a few drops of sodium hydroxide solution. Result? If the precipitate has the formula $Fe(OH)_2$, write the equation. Classify the materials that react in this case.

Treat about 3 c.c. of potassium ferrocyanide solution, $K_4Fe(CN)_6$, with a few drops of sodium hydroxide solution. Result? Why is $Fe(OH)_2$ not precipitated as before? Of what *radical* is the iron a part?

c. **Double decomposition between salts and acids.** Review Experiments XV, *b*, XX, *a*, and XXII, *m*, and rewrite the equations here. Use the proper arrows for precipitates or escaping gases. Classify, as in *a*, the materials that react in the case of salts and acids.

Grind together about 1 c.c. each of sodium bicarbonate and tartaric acid in a dry mortar. Is there any evidence of a reaction? Now add water, and account for the difference. Write the equation (*cf.* § 280 of text).

d. **Double decomposition between acids and bases.** Review Experiments XXVII to XXIX. Write here the equations involved. Classify the materials of acids and bases that react by double decomposition. What **one substance** (not class) is always formed in neutralization? What materials unite to produce it? What becomes of the other two? For which materials do we **test** with *indicators* like litmus and phenolphthalein?

EXPERIMENT XXXI.

HYDROLYSIS AND REPLACEMENT.

Materials. — Litmus paper, antimony chloride, bismuth nitrate, iron nails (brads), copper turnings, and zinc (strips or granulated); concentrated hydrochloric and nitric acids; solutions of aluminum chloride, cupric sulphate, mercurous nitrate, and silver nitrate.

a. To a small amount (half a c.c.) of antimony chloride, $SbCl_3$, add 5 c.c. water, and shake the two together. Result? If the product first formed is *antimony* $SbOH$ *dihydroxychloride*, $SbOH$, write the equation. Cl

b. To the precipitate add concentrated hydrochloric acid, a drop at a time, warming after each drop. Result? If the solution contains antimony chloride, $SbCl_3$, write the equation.

c. Add the solution obtained in *b* to 50 c.c. water. Result? Add concentrated hydrochloric acid again. Result?

d. Compare the equations of *a* and *b*. Write one of them, using, instead of the equality sign, the *double arrow* $\rightleftharpoons$. In which direction does the reaction go chiefly when an excess of water is used? When an excess of acid is used?

e. Repeat the experiment with *bismuth nitrate*, $Bi(NO_3)_3$, and water, and use concentrated nitric acid instead of hydrochloric acid. Write the equation.

f. Recall Experiment XXVI for the reaction of *salt* with litmus. For the reaction of sodium carbonate. Try the action of aluminum chloride solution with red and blue litmus paper. Complete the equations, —

$$NaCl + HOH \rightleftharpoons ? + ?$$
$$Na_2CO_3 + 2HOH \rightleftharpoons ? + ?$$
$$AlCl_3 + 3HOH \rightleftharpoons ? + ?$$

For which of these three reactions do you get no evidence from the behavior with litmus? Of what reaction is hydrolysis the reverse? Why is it so incomplete as compared with its reverse?

g. **Replacement.** To 5 c.c. cupric sulphate solution in a test tube add several small iron nails (brads) and let stand over night. Result? What change has occurred in the color of the solution. What is the precipitate? Write the equation.

Repeat, using *mercurous nitrate* ($HgNO_3$) solution with copper turnings. Equation?

Repeat again, with strips of zinc, or granulated zinc, and *silver nitrate* solution. Result and equation? Compare the results with the action of a metal on an acid, as in Experiment VIII.

EXPERIMENT XXXII.

NITROGEN.

Apparatus. — 100 c.c. flask, wire gauze, ring stand, clamp, stopper, delivery tube, pneumatic trough, collecting bottle.

Materials. — Sodium nitrite, $NaNO_2$; ammonium chloride, NH_4Cl.

a. Support a flask by means of a clamp about its neck, and place under it the wire gauze. Put into the flask 5 c.c. *powdered* sodium nitrite, 5 c.c. ammonium chloride, and 50 c.c. water.

Attach the stopper and delivery tube; the delivery tube extends to a pneumatic trough containing water and an inverted collecting bottle full of water.

b. Have ready your evaporating dish full of *cold* water. Heat the flask *gently* until a regular but not too rapid stream of gas escapes. If at any time during the heating the evolution of gas (nitrogen) becomes *violent*, remove the delivery tube from the water, take away the flame and wire gauze, and bring the evaporating dish of cold water up over the bottom of the flask. Let two test tubes of gas escape (why?); then fill the bottle with it.

c. Determine the odor and color of the gas, also its relation to combustion.

Write the equations for the *stages* of the reaction; also the complete equation.

EXPERIMENT XXXIII.

AMMONIA.

Apparatus. — Mortar and pestle, stirring rod, test tubes, 100 c.c. flask, stopper, two right-angle tubes, collecting bottles, gauze.

Materials. — Glue, quicklime, litmus, hydrochloric acid, ammonium chloride, ammonium nitrate, ammonium sulphate, sodium hydroxide solution, potassium hydroxide solution.

a. Mix in a mortar about one half gram glue and 2 grams quicklime, and heat the mixture in a test tube. Hold in the mouth of the tube, without touching the tube, a piece of moist blue litmus paper. Red litmus paper. A glass rod which has been dipped into concentrated hydrochloric acid. Results? Note odor. What is it?

b. To about one half gram ammonium chloride in a test tube add 2 c.c. ten per cent sodium hydroxide solution, and warm gently. Odor? Effect of gas on litmus? On a rod wet with concentrated hydrochloric acid?

c. Repeat *b*, using ammonium nitrate and sodium hydroxide solution. Results? Use ammonium sulphate and ten per cent potassium hydroxide solution. Results? The gas formed in the above cases is ammonia, NH_3.

d. In a 100 c.c. flask mix 10 grams powdered ammonium chloride and 20 grams powdered quicklime. Odor? Support the flask on wire gauze and attach the stopper and a delivery tube bent twice at right angles (see Experiment XXI, *a*). Have the second right-angled tube turned *upward*. On a small ring fastened high up on the ring stand, lay a piece of cardboard with a small hole in it; through the hole pass the delivery tube, and invert over the delivery tube the *dry* receiver (bottle) intended to collect the ammonia.

e. Heat *very gently*. When the bottle is full of gas, — test this by waving air from the bottle toward the nose, — cover it and place it mouth down upon the table. Fill three bottles with the gas. Now turn the end of the delivery tube down, so that it just touches the surface of 10 c.c. water in a test tube.

After a minute raise the test tube *carefully* about 2 cm. Do the bubbles of ammonia rise to the surface of the water? Why? Lower the test tube again until the delivery tube just touches the water, and continue heating the flask gently three minutes. Remove the test tube; and *then* extinguish the flame. Let the flask cool not in contact with the wire gauze or any conductor. Why?

f. Did you notice any change in the temperature of the water of the test tube? Explain. Save this liquid.

g. From the method of collecting the gas compare its specific gravity with that of air. Is there any evidence of water in the generating flask?

h. Test the gas in the first receiver with litmus paper — keep mouth of receiver down. Test relation of this gas to combustion. Results?

Thrust up into the receiver a glass rod which has been dipped in concentrated nitric acid. Results? The smoke is ammonium nitrate, NH_4NO_3. Write the equation.

i. Place the second bottle mouth downward in a pan of water. Result? Explain.

j. Warm the bottom and sides of a clean, dry bottle (having a mouth of the same size as that of the third bottle of ammonia) by moving it *quickly* to and fro in the Bunsen flame; put into it five drops concentrated hydrochloric acid, and place over the bottle of hydrochloric acid gas thus obtained, the bottle of ammonia. Hold the mouths of the bottles firmly together and reverse their positions, so that the ammonia bottle is below the other. Results? What is the product?

k. Examine the solution of ammonia made in *e.*

What effect has it upon litmus? Hold a piece of moist red litmus about 2 cm. above the solution. Result? Explain.

Put 5 c.c. of the solution into a beaker, note the odor, and let beaker stand for twenty-four hours. Is the odor as strong as before? Inference?

l. Put about 5 c.c. of the ammonia solution of *e* into an evaporating dish, and boil it gently for five minutes. Compare odor after boiling with that of some of the original solution.

m. Heat a small amount of ammonium chloride for some time on a piece of porcelain or on platinum. Result?

n. Write the equations for the reactions which took place in *b*, *c*, *d*, and *e*, as double decomposition equations; then show the dissociation of ammonium hydroxide.

EXPERIMENT XXXIV.

NITRIC ACID.

Apparatus. — 100 c.c. flask, cork stopper, delivery tube (in one piece), test tube, beaker, wire gauze, ring stand.

Materials. — Potassium nitrate, concentrated sulphuric and nitric acids, white silk thread, indigo solution, ferrous ammonium sulphate or ferrous sulphate, and copper nitrate.

a. Use apparatus of Experiment XI, Fig. 96. Into the flask put 5 g. potassium nitrate and 10 c.c. concentrated sulphuric acid. Attach the stopper and the delivery tube. The delivery tube must be *in one piece without rubber connections.* Put the end of the delivery tube

into a test tube resting in a beaker of cold water. The test tube will serve as a *condenser*.

b. Warm the flask *gradually* over the wire gauze. Result? Color of fumes? Keep the end of the delivery tube out of the liquid which condenses in the test tube.

When no more liquid distills over, remove the delivery tube. Only then remove the flame.

The liquid collected is *nitric acid.* Complete the equation,

$$KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + ?$$

What is the color of the acid?

c. Let the flask cool thoroughly. Result? Name the crystalline product. Finally, add water and pour the resulting solution into the sink.

d. Add 1 c.c. of the nitric acid you have made to 1 c.c. of water, and test the action of a drop (use the glass rod) upon litmus. Result?

Into your diluted acid put a piece of white woolen yarn, and warm gently. Remove the yarn. How has it *changed?*

To 1 c.c. of your dilute acid add a few drops of indigo solution. Result?

e. What color does your undiluted acid give to the skin? Will ammonium hydroxide remove the stain?

f. Treat about 2 c.c. of ferrous ammonium sulphate or of ferrous sulphate in a test tube with 15 c.c. water and shake vigorously. Take 5 c.c. *of this solution* in a test tube, add two drops of dilute nitric acid, incline the tube at an angle of about forty-five degrees, and pour about 3 c.c. concentrated sulphuric acid down the side of

the tube. Describe what takes place where the concentrated acid, which is below, meets the solution.

g. Repeat *f*, using a solution of *potassium nitrate* instead of nitric acid. Result? Repeat again with *cupric nitrate* instead of the acid. Result?

h. If the test just tried is a general one for *all nitrates*, how would you proceed to test a solution for the presence of a nitrate or nitric acid?

EXPERIMENT XXXV.

NITRITES.

Apparatus. — Iron dish, stout iron wire, beaker, test tubes.
Materials. — Potassium nitrate, lead, filter paper, dilute sulphuric acid.

a. Melt together in a shallow iron dish 10 grams potassium nitrate, KNO_3, with about 20 grams of lead. Keep the mixture at red heat, and stir twenty minutes with a stout iron wire or a nail held in iron tongs.

b. When the mass is cool add 20 c.c. water, heat to boiling for a few minutes, take out the unused lead, and then filter.

The residue on the filter is lead oxide, PbO. Its color? The filtrate contains potassium *nitrite*, KNO_2, and unchanged nitrate. The reaction is a *reduction* of potassium nitrate by lead, as is shown in the equation,

$$KNO_3 + Pb \longrightarrow KNO_2 + PbO.$$

c. Treat the solution of potassium nitrite from *b* with dilute sulphuric acid. Result? Treat some potas-

sium nitrate solution in a test tube with dilute sulphuric acid, and compare results.

d. The brown gas is nitrogen trioxide, N_2O_3, formed as shown by the equations,

$$KNO_2 + H_2SO_4 \longrightarrow KHSO_4 + HNO_2.$$
$$2\ HNO_2 \longrightarrow N_2O_3 + H_2O.$$

EXPERIMENT XXXVI.

NITROGEN TETROXIDE.

Apparatus. — Test tubes, doubly bent delivery tube.
Material. — Powdered lead nitrate, $Pb(NO_3)_2$.

a. Heat 5 grams powdered lead nitrate carefully in a test tube (use a holder), keeping the tube *in constant motion.* Result?

When the tube is full of gas, attach a stopper and a delivery tube with its longer arm *turned down.* Fill a dry test tube with the evolved gas by displacement of air.

b. Invert the test tube of gas in a beaker of water, and leave it a few minutes. Result? Test the residual gas with a pine splinter having a spark on the end of it. Result?

c. The brown gas is *nitrogen dioxide,* NO_2, mixed with *nitrogen tetroxide,* N_2O_4.

The equation is,

$$Pb(NO_3)_2 \longrightarrow PbO + N_2O_4 (i.\ e.,\ 2\ NO_2) + O.$$

d. The lead oxide in the test tube may nearly all be

removed by adding to the cold tube dilute nitric acid and heating *carefully*.

EXPERIMENT XXXVII.

NITRIC OXIDE.

Apparatus. — Generating bottle (250 c.c.), two stoppers (one two-holed and one one-holed), funnel tube, delivery tubes, pneumatic trough, wide-mouth collecting bottles, cardboard or glass covers.

Materials. — Copper (granulated or turnings), nitric acid, ferrous sulphate, splinter of pine, red phosphorus.

a. Into a generating bottle (250 c.c.) put enough granulated copper to cover the bottom. Attach stopper containing funnel tube and delivery tube. Add through the funnel tube enough dilute nitric acid to immerse the lower end of the tube, and then concentrated acid, as necessary, to give brisk action. The gas produced is *nitric oxide*, NO. *If the acid is too concentrated, considerable nitrogen tetroxide is produced.*

b. Fill a bottle over water with the gas, and expose it to the air. Result? From the result tell why the gas in the generating flask was originally brown.

c. Pass the gas about three minutes into 10 c.c. concentrated ferrous sulphate solution in a test tube. Result? Save the solution for *g*.

d. Collect a second and a third bottle full of the gas over water. Cover one of the bottles, remove it from the water, turn it mouth upward, and put into it a lighted splinter. Result?

e. Repeat *d* with the last bottle of the gas, using a deflagrating spoon containing *briskly burning* **red** *phosphorus,* instead of the splinter. Compare results. Is nitric oxide a supporter of combustion, or not?

f. Attach to the test tube of solution from *c* a one-holed stopper and a delivery tube. Warm gently and collect the evolved gas over water in a test tube. Expose the gas to the air. Result? Conclusion?

The brown liquid obtained in *c* contains a compound of ferrous sulphate and nitric oxide ($FeSO_4.NO$).

See Experiment XXXIV, *f,* where the formation of a brown ring of this compound was used as a test for nitric acid and the nitrates.

g. Pour 25 c.c. of the solution (its color?) left in the generating flask into a beaker, add any unused copper, and let the beaker stand (in a gas chamber if possible) until all action ceases. There should be an *excess* of copper. Pour the liquid into an evaporating dish, and evaporate on a wire gauze to about 10 c.c. Dip into the liquid a glass rod, and see if the liquid which sticks to the rod will solidify on cooling. If so, let the dish cool; if not, evaporate off about 2 c.c. more, and try again. Result?

The substance obtained is *cupric nitrate,* $Cu(NO_3)_2$.

Write the *partial* and *complete* equations.

EXPERIMENT XXXVIII.

NITROUS OXIDE.

Apparatus. — Test tubes, stopper, delivery tube, pneumatic trough, clamp, ring stand, collecting bottle.

Materials. — Ammonium nitrate, pine splinter.

a. Into a test tube provided with stopper and delivery tube put about 10 grams ammonium nitrate, and fasten the test tube by a clamp to the ring stand. The test tube should be inclined at an angle of about forty-five degrees.

Invert a bottle of water (best *warm*) in the pneumatic trough, but do not put the delivery tube into the water until *c*.

b. Heat the test tube *gently* with a moving flame. Result? Warm more. Result?

When a steady stream of gas is evolved, hold over the end of the delivery tube a cold and dry beaker. What collects in it?

c. Now put the end of the delivery tube into the pneumatic trough, and fill the collecting bottle with the gas. The gas is *nitrous oxide*, N_2O. Write the equation.

Set the bottle of gas mouth upward and covered upon the table, and then fill a test tube with the gas.

Note. — *Be sure to take the delivery tube out of the water before you remove the flame.*

d. To the test tube of gas add 5 c.c. *cold* water, close the tube tightly with the thumb, and shake vigorously. Open the tube under water. Result?.

e. What is the odor of the gas in the bottle? Insert into it a pine splinter with a glowing tip. Result?

What gas resembles nitrous oxide in its *vigorous* support of combustion?

EXPERIMENT XXXIX.

PHYSICAL PROPERTIES OF SULPHUR.

Apparatus. — Test tubes, filter, funnel, evaporating dish, beaker.

Materials. — Powdered roll sulphur, carbon disulphide.

a. Test the solubility of sulphur as follows: In a test tube shake 1 c.c. powdered roll sulphur with 5 c.c. water; filter, and evaporate the filtrate in an evaporating dish. Result? Conclusion?

What is the odor of sulphur? Its taste?

b. Treat *not more than* 1 *c.c.* powdered sulphur in a test tube with 5 c.c. carbon disulphide.

Caution. — Carbon disulphide is *inflammable. Do not bring it near a flame.*

Close the test tube with the thumb, and shake it thoroughly. Result? Pour the contents of the tube into a *small* beaker, and set this aside in a gas chamber (*not in your cupboard*) until the carbon disulphide evaporates. Result? What is the shape of the larger crystals?

c. Fill a test tube one-third full of sulphur, hold it inclined at an angle of about forty-five degrees, and heat it carefully. Note the changes through which the sulphur passes as you raise its temperature.

What is the color of the liquid formed by melting the sulphur? Is it *viscous* (thick) or *limpid* (thin; easily poured)? Pour a drop of it into water. Color of the product? Is it hard or soft? Sulphur melts at about 114° C.

d. What change does the sulphur undergo when you heat it further? Tilt the test tube to an *almost* horizontal position from time to time *until you find the point at which the liquid cannot be poured.* Then continue heating, and notice that the sulphur becomes limpid again.

Finally, heat the sulphur to boiling. You will know that boiling is taking place when you see the dark brown liquid condensing upon the upper (cooler) parts of the tube. Sulphur boils at 446° to 448° C.

e. Pour the boiling sulphur into a beaker of *cold* water. Result? Color of the product? Is it hard or soft? Elastic or brittle? Keep this for several weeks, noting from day to day any changes that take place.

EXPERIMENT XL.

CHEMICAL PROPERTIES OF SULPHUR.

Apparatus. — Deflagrating spoon, 250 c.c. bottle, cardboard, test tube.

Materials. — Sulphur, blue litmus paper, powdered iron.

a. Put about 1 c.c. powdered sulphur in a deflagrating spoon, heat it in the flame until it burns briskly, and then put the spoon into a bottle of air. Keep the bottle covered with cardboard having a hole in it for the handle of the spoon.

Let the sulphur burn as long as it will. Name the product of the combustion. What is its physical state? Its odor? Try its effect upon *wet* blue and red litmus papers.

b. Mix in a mortar 5.6 grams powdered iron and 3.2 grams powdered sulphur, and put the mixture into a test tube. Heat the lower portion of the tube for a moment in the Bunsen flame. Result? When action begins, withdraw the test tube from the flame. Describe all that takes place.

c. When the product is cool, break the test tube, and remove the solid lump. Describe the product. It is *ferrous sulphide,* FeS.

Write the equation for its formation. Save the solid for Experiment XLI.

EXPERIMENT XLI.

HYDROGEN SULPHIDE.

Apparatus. — Test tubes, stopper, and delivery tube.

Materials. — Ferrous sulphide from Experiment XL; dilute sulphuric acid; solutions of cupric sulphate, barium chloride, lead nitrate, cadmium sulphate, sodium hydroxide, and litmus.

Note. — Perform this experiment in a gas chamber, or where there is a *good* draught.

a. Treat the lump of ferrous sulphide made in Experiment XL with dilute sulphuric acid in a test tube. Result? *The gas is hydrogen sulphide,* H_2S. Attach a stopper and delivery tube, and fill a test tube held mouth

upward with the gas. Apply a match to the test tube. Result? Note odor of the burning gas. Result? Complete the equation,

$$H_2S + O_2 \longrightarrow$$

b. Pass the hydrogen sulphide gas from the generating tube into 5 c.c. dilute cupric sulphate ($CuSO_4$) solution in a test tube. Result? Continue about one minute. Now see that the delivery tube is clean, and pass the gas three or four minutes into 15 c.c. water in a test tube. Then wash out the generating tube *thoroughly.*

c. Filter the test tube of cupric sulphate into which you have passed hydrogen sulphide. Compare the color of the filtrate with that of the cupric sulphate taken. Conclusion?

The black residue is cupric sulphide, CuS. Write the equation for the action of *hydrogen sulphide* upon *cupric sulphate.*

d. Add a few drops of the hydrogen sulphide solution to 2 c.c. lead nitrate solution, $Pb(NO_3)_2$. Result? If the insoluble product is lead sulphide, PbS, write the equation.

Repeat, using *cadmium sulphate* solution in place of *lead nitrate.* Result? If the insoluble product is *cadmium sulphide,* CdS, write the equation.

e. Test the reaction of the hydrogen sulphide solution with red and blue litmus papers. Results? Conclusion?

Add to the remainder of the hydrogen sulphide solution 1 c.c. sodium hydroxide solution. The solution now contains *sodium sulphide,* Na_2S. Write the equation.

f. How would you make ammonium sulphide solution, $(NH_4)_2S$? Write the equation.

EXPERIMENT XLII.

SULPHUR DIOXIDE.

Apparatus. — 100 c.c. flask, ring stand, wire gauze, stopper and delivery tube, 2 collecting bottles, test tubes, beaker, evaporating dish.

Materials. — Granulated copper, concentrated sulphuric acid, red flower, red cheese cloth, crystals of cupric sulphate, dilute sulphuric acid, sodium hydroxide solution, litmus paper, concentrated nitric acid, potassium permanganate and potassium dichromate solutions.

a. In a 100 c.c. flask put about 5 grams copper and add 25 c.c. concentrated sulphuric acid. Support the flask in a ring stand, upon wire gauze, and attach a stopper and a doubly bent delivery tube reaching *almost* to the table.

b. Heat the flask *carefully.* When brisk effervescence begins, moderate the heat. Collect 2 bottles of the gas as you did chlorine in Experiment XXI, *b.* Tell when each bottle is full by the odor. Stopper the bottles. Collect, also, a test tube of the gas and put it, mouth down, into a beaker of water. Explain the result.

Wave a little of the escaping gas toward the nose. Odor?

The gas is *sulphur dioxide,* SO_2.

c. Put the end of the delivery tube *just at the surface* of 10 c.c. water in a test tube. When the gas is coming off freely, raise the test tube about 1 cm. What evidence is there that the gas is dissolving? Lower the test tube to its former position and keep it there five minutes. Then

remove the delivery tube from the water, extinguish the flame, and let the generating flask cool in position, *out of contact with the wire gauze.*

Stopper the test tube containing the solution of the gas, and keep it.

d. Into one bottle of sulphur dioxide gas put a few petals of some red flower, *e. g.*, a carnation; also a small piece of wet, red cloth such as you used with chlorine in Experiment XXI, *e.* Results?

Test the action of sulphur dioxide upon blue litmus paper. Result?

e. To the second bottle of sulphur dioxide add 4 drops of concentrated nitric acid, stopper the bottle, and shake it. Results? Add 5 c.c. water, stopper once more, shake, and pour the liquid into a test tube. Save this for Experiment XLIV, *c.*

f. Note the taste of a drop of the sulphur dioxide solution made in *c.* What is the action of 1 c.c. of it upon 1 c.c. potassium permanganate solution ($KMnO_4$)? Repeat with potassium dichromate solution instead of potassium permanganate. Result?

Sulphur dioxide solution contains sulphurous acid, H_2SO_3.

g. Neutralize the remainder of the sulphurous acid in an evaporating dish with 10 per cent sodium hydroxide solution and evaporate to dryness. The resulting substance is *sodium sulphite,* Na_2SO_3. Describe it.

Complete the equation,

$$2\ NaOH + H_2SO_3 \longrightarrow ? + ?$$

h. Treat the sodium sulphite in a test tube with a little dilute sulphuric acid, and warm. Note the odor.

The sulphite is decomposed by the acid thus: —

$$Na_2SO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2SO_3 \ (i.\ e.,\ SO_2 + H_2O).$$

i. When the generating flask is *cold*, add to it 25 c.c. water, shake *carefully*, and heat the flask *cautiously* over wire gauze. Filter the resulting liquid. What is the color of the filtrate? Concentrate it to about 15 c.c., and let it cool. Result? Compare the product with blue vitriol, $CuSO_4 . 5\ H_2O$. Complete the equation,

$$Cu + H_2SO_4 \longrightarrow$$

EXPERIMENT XLIII.

SULPHURIC ACID.

Apparatus. — File or blue paraffin pencil, test tube, beaker, balances.

Materials. — Concentrated sulphuric acid, sugar, cotton, cloth, paper, splinter.

a. By means of a file or a blue paraffin pencil mark off about 10 c.c. on a clean, dry test tube, set the tube in a clean beaker, and get the weight of both test tube and beaker together. Now fill the tube up to the mark with concentrated sulphuric acid, wipe off any acid adhering to the mouth of the test tube, and get the weight of acid + beaker + test tube.

Return the acid to the bottle, rinse the test tube, and dry it on the outside. Then fill the tube up to the mark with water, and get the weight of water + beaker + test tube.

Record your results thus: —

		Grams.
Wt. of test tube + beaker + sulphuric acid	=	
Wt. of test tube + beaker	=	
∴ Wt. of sulphuric acid taken	=	
Wt. of test tube + beaker + water	=	
Wt. of test tube + beaker	=	
∴ Wt. of water taken	=	

From the results calculate the specific gravity of your sulphuric acid.

b. Heat *one* drop — no more — of concentrated sulphuric acid in an evaporating dish over wire gauze. Result?

c. Put into a test tube a splinter of wood and add 5 c.c. concentrated sulphuric acid. Let stand fifteen minutes. Try the effect of a drop of concentrated sulphuric acid on paper; upon cotton cloth. Wait for the result if it is not immediate. Results.

d. Into a small beaker put 10 grams sugar and 5 c.c. water, and stir thoroughly. Now add 10 c.c. concentrated sulphuric acid. Results? Describe the product.

EXPERIMENT XLIV.

SULPHATES.

Apparatus. — Test tubes.

Materials. — Concentrated sulphuric acid; solutions of barium chloride, cupric sulphate, sodium sulphate; dilute hydrochloric acid; liquid from Experiment XLII, *e*.

a. To 10 c.c. water in a test tube add 1 c.c. concentrated sulphuric acid. Result? Heat the diluted acid to boiling, and add 5 c.c. barium chloride solution, $BaCl_2$. Result?

The precipitated substance is barium sulphate, $BaSO_4$. If the other product is hydrochloric acid, write the equation.

Let the precipitate settle, pour off the *supernatant* liquid, and add 10 c.c. dilute hydrochloric acid to the precipitate. Does the precipitate dissolve?

b. Repeat *a*, using instead of dilute sulphuric acid 5 c.c. of a solution of cupric sulphate, $CuSO_4$. Results? Equation?

Repeat again, using 5 c.c. of sodium sulphate solution, Na_2SO_4, with 5 c.c. barium chloride solution. Result? Equation?

Note. — *In general*, if a solution gives with barium chloride solution a white precipitate *insoluble in dilute hydrochloric acid*, we are *reasonably* sure that the unknown solution contains sulphuric acid or a *sulphate.*

c. Treat the liquid obtained in Experiment XLII, *e*, with barium chloride solution. Result? What effect did nitric acid have upon the sulphur dioxide? Complete the equation,

$$SO_2 + O + H_2O \longrightarrow$$

EXPERIMENT XLV.

CARBON.

Apparatus. — Tongs, test tubes, iron dish with a cover, beaker.

Materials. — Charcoal (lumps and powder), graphite (pencil lead), soft coal, hydrogen sulphide solution, litmus solution, brown sugar, animal charcoal.

a. Hold a piece of charcoal in the Bunsen flame (use tongs) and describe its combustion. Repeat with *graphite* (pencil lead) and with soft coal.

b. Fill an *old* test tube one-fourth full of bits of wood, and heat. Results? Bring a burning match to the mouth of the tube. Result? Describe the other products. What is the residue?

c. Hold a piece of wood charcoal under water in a beaker for two minutes. What appears on its surface? Conclusion?

d. Heat powdered wood charcoal or animal charcoal for five minutes in a covered iron dish. Let it cool, and add 2 c.c. of it to 5 c.c. *hydrogen sulphide* solution. Shake thoroughly and filter. Compare odor of filtrate with that of the solution taken. Conclusion?

e. Boil 5 c.c. *litmus* solution two minutes with 2 c.c. of the freshly ignited charcoal, and filter. Result? *Repeat*, using 5 c.c. of a solution of brown sugar with 2 c.c. fresh charcoal. Result?

EXPERIMENT XLVI.

CARBON DIOXIDE, I.

Apparatus. — Generating bottle, stopper with thistle tube and delivery tube, pneumatic trough, beaker, test tubes, and collecting bottles.

Materials. — Marble, hydrochloric acid, litmus, lime-water.

a. Place in a bottle enough marble (a form of *calcium carbonate,* $CaCO_3$) to cover the bottom, add enough water to close lower end of the thistle tube, insert stopper, and add concentrated hydrochloric acid through the thistle tube. Add more acid when it is needed. Collect the *carbon dioxide* (CO_2) over water, rejecting the first bottle of the gas. See, also, Experiment XX.

b. Put into a bottle of the gas wet litmus paper (red and blue) and a burning match. Results?

c. Pour a bottle of the gas into a beaker of air. Test the gas in the beaker with a burning match. Result? Conclusion as to the specific gravity of the gas?

d. Fill a test tube with the gas by air displacement, add 5 c.c. *cold* water, close tube securely with thumb, shake vigorously, and open under water. Result? Conclusion?

e. Pass the gas into lime-water, $Ca(OH)_2$. Result? Let the precipitate settle. It is *calcium carbonate.* Its formation with lime-water is a **test** for carbon dioxide (*cf.* Experiment V, *e*). Now pass a vigorous stream of the gas into the tube five minutes. Result? Boil the contents of the tube. Result?

EXPERIMENT XLVII.

CARBON DIOXIDE, II.

Apparatus. — Beakers, delivery tube, test tubes.

Materials. — Lime-water, sodium bicarbonate, tartaric acid.

a. Mix 2 c.c. each of *sodium bicarbonate* ($NaHCO_3$) and *tartaric acid* ($H_2C_4H_4O_6$) in a mortar. Is a change apparent? Put half of the powder into a test tube, and add water. Result? Identify the gas.

b. Put the remainder of the mixture from *a* in a test tube, add 10 c.c. water, and, as soon as you are able, imprison the gas by holding your thumb upon the mouth of the test tube. Effect upon the effervescence? Now remove your thumb. Effect? Explain.

c. Blow your breath through a delivery tube into 5 c.c. lime-water. Result? Conclusion?

d. Expose 5 c.c. *clear* lime-water to the air for several hours. Result? How does carbon dioxide get into the air (*cf.* Experiment V, *e*)?

EXPERIMENT XLVIII.

REDUCTION BY CARBON. EFFECT OF HEAT ON CARBONATES.

Apparatus. — Ignition tube, delivery tube, rubber connector, test tubes.

Materials. — Lead monoxide, powdered charcoal, lime-water, magnesite.

a. Mix 1 c.c. lead monoxide, PbO, with one-third its volume of powdered charcoal, on *smooth* paper. Into the ignition tube put enough of the mixture to make a layer 1 cm. thick, support the tube almost horizontally, and attach a delivery tube leading into 5 c.c. lime-water. Heat the lead monoxide *persistently* for ten minutes, cool it, and pour it out on the table. Result? What gas was evolved? Write the equation.

b. Fill the ignition tube one-fifth full of chips of *magnesite*, $MgCO_3$, and set it up as in *a*. Heat persistently. What gas is evolved? What, then, does the residue contain? Write the equation.

EXPERIMENT XLIX.

FLAMES.

Apparatus. — Bunsen burner and tongs.
Materials. — Candle, piece of porcelain, white paper.

a. Examine carefully the non-luminous flame. Sketch a vertical section of it *as you see it.* Make drawing 4 cm. long.

b. Do the same with a *luminous* Bunsen flame 2 cm. high. Repeat with a candle flame.

c. Press the colorless Bunsen flame for a moment upon paper lying on your table. The paper should not burn up. Result?

Hold a piece of glass tubing about 1 dm. long at an angle of forty-five degrees, with the lower end inside the central part of the non-luminous flame, and apply a lighted

match to the other end. Result? What do these experiments show as to the inner region of the flame?

d. Hold a piece of porcelain (broken evaporating dish) by means of tongs in the luminous flame. Result? What substance is in excess here? Now hold the porcelain in the colorless flame for some time. Result? What is in excess in this flame?

EXPERIMENT L.

BROMINE.

Apparatus. — Beaker, 100 c.c. flask, test tubes.

Materials. — Potassium bromide, powdered manganese dioxide, dilute sulphuric acid, litmus paper, calico, carbon disulphide, chlorine-water, sodium hydroxide.

Caution. — If possible, work in a gas-chamber or hood.

a. Into a flask put an eighth of a test tube of potassium bromide (KBr) crystals, half as much powdered manganese dioxide, and half a test tube of dilute sulphuric acid. Support the flask over wire gauze, and attach the cork stopper and a doubly bent delivery tube reaching into a test tube three-fourths full of cold water. The delivery tube must be without rubber connections. The test tube should rest in a beaker of water (*cf.* Experiment XI).

b. Warm the flask *carefully* until a dark brown distillate passes over. Is it heavier or lighter than water? **Do not inhale the vapor,** and do not get liquid bromine on your hands.

When no more bromine comes over, remove first the delivery tube and then the flame. The light-brown solution is "bromine-water."

c. Wave the air from the test tube toward the nose. Odor of bromine? Pour off as much bromine-water as possible without pouring out the bromine, and add more water to the bromine. Pour a few drops of the bromine-water upon litmus paper and upon colored calico. Results?

d. To 3 c.c. water in a test tube add 1 c.c. *carbon disulphide*, close tube with thumb, and shake vigorously. Results? Where is the carbon disulphide? Now add $\frac{1}{4}$ c.c. bromine-water and shake again. Result to the color of the water? To that of the carbon disulphide? *This effect on the carbon disulphide is a test for* **free** *bromine.*

e. To 5 c.c. of potassium bromide solution add 1 c.c. carbon disulphide and shake. Result? Now add two or three drops of *chlorine-water* (make as in Experiment XXI, *i*), close the tube, and shake it as before. Results? Action of chlorine on potassium bromide? Equation?

f. To the liquid bromine saved from *c* add sodium hydroxide solution, a cubic centimeter at a time, shaking thoroughly. (Do not close the tube with the thumb!) Result? The equation is, —

$$2\,NaOH + 2\,Br \longrightarrow NaBr + \underset{\text{sodium hypobromite}}{NaBrO} + H_2O.$$

EXPERIMENT LI.

IODINE AND HYDRIODIC ACID.

Apparatus. — Test tubes, beaker, flask.

Materials. — Potassium iodide, manganese dioxide, sulphuric acid, iodine, carbon disulphide, chlorine- and bromine-water, starch, alcohol, hydrogen sulphide, silver nitrate solution, sodium carbonate, litmus.

a. Powder *potassium iodide* (KI), mix 1 c.c. of it with a c.c. of manganese dioxide, add 2 c.c. water and then 1 c.c. concentrated sulphuric acid. Result? When the action slackens, warm the tube gently, and then let it cool. Describe what you find in the tube. It is *iodine.* Compare its preparation with that of chlorine and bromine.

b. Warm a crystal of iodine (*gently*, not to boiling) with 10 c.c. water for a few seconds. Does the iodine dissolve *readily?* Cool the water and add 3 c.c. of it to 1 c.c. carbon disulphide. Shake the closed tube. Result? *This is a test for* **free** *iodine.* Save the iodine solution.

c. Shake 5 c.c. potassium iodide solution with 1 c.c. carbon disulphide. Result? Add a drop of chlorine-water and shake again. Result? What effect has chlorine upon potassium iodide? *Repeat*, using bromine-water instead of chlorine-water. Write both equations.

d. Make a **starch solution** as follows: Mix 2 c.c. powdered starch with 5 c.c. cold water, and pour the emulsion into 30 c.c. boiling water. Boil for a minute or

two, and then cool. To 3 c.c. of the solution add a drop of the iodine solution of *b*, shaking. Result?

To 3 c.c. of the starch solution add one drop of a potassium iodide solution and then one drop of chlorine- or bromine-water. Result?

e. Heat a crystal or two of iodine in a dry, inclined test tube. Result? Let cool. Result? Effect of iodine on the skin? On wood and paper?

f. To the iodine of *e* add 5 c.c. *ethyl alcohol*, C_2H_5OH. In which is iodine more soluble, water or alcohol? An alcoholic solution is often called a *tincture.*

g. To one-half a c.c. of powdered iodine in a flask add 20 c.c. water and then pass in hydrogen sulphide (gas-chamber!) until the iodine disappears. Results? Boil the solution gently two minutes, and filter it. Identify the precipitate by igniting a little on a piece of porcelain. Odor? Test the filtrate with red and blue litmus. Results? Add a drop of it to 1 c.c. silver nitrate solution. Result? Add some to 1 c.c. solid sodium carbonate Result? What substances are formed from hydrogen sulphide and iodine? Equation?

EXPERIMENT LII.

COMPARISON OF THE HALOGEN ACIDS.

Materials. — Potassium chloride, bromide, and iodide; concentrated sulphuric acid, litmus.

a. Three test tubes have small amounts of potassium chloride, bromide, and iodide, respectively; treat each with a few drops of concentrated sulphuric acid. Re-

sults? Blow your breath across the mouth of each tube. Result? Test the gas of each with blue litmus. Result? Note carefully the odor of each gas. What odors beside that of the acid do you get in the tube of potassium iodide? Heat this tube. Result?

b. Which tube gives a colorless gas? What colors the gas in each of the two other cases? From the amount of coloration, tell which of the three halogen acids is most easily decomposed into its elements. Which least.

EXPERIMENT LIII.

HYDROGEN PEROXIDE.

Materials. — Hydrochloric acid, barium peroxide, starch solution, potassium iodide solution, manganese dioxide, potassium permanganate, ether, potassium dichromate solution, splinter.

a. To 25 c.c. water add 5 c.c. concentrated hydrochloric acid and then 3 grams powdered *barium peroxide*, BaO_2, a little at a time, stirring. Filter the solution; it should contain *hydrogen peroxide*, H_2O_2.

b. To 5 c.c. starch solution add a drop of potassium iodide solution, and then a few drops of the hydrogen peroxide solution. Result?

c. To 3 c.c. of the solution of *a* add 3 c.c. ether. Do they mix? Is the ether above or below? Now add *one drop* of potassium dichromate solution. Close tube and shake *gently*. Result?

d. To 5 c.c. of the hydrogen peroxide solution add 1 c.c. powdered manganese dioxide. Result? Test gas with a glowing splinter. Result?

e. To three crystals of potassium permanganate in a test tube add 2 c.c. water and then 5 c.c. of the hydrogen peroxide solution. Result? Test with glowing splinter. Result?

EXPERIMENT LIV.

PHOSPHORUS AND PHOSPHORIC ACID.

Apparatus. — Test tubes, small ignition tube, tongs, evaporating dish, file.

Materials. — Red and yellow phosphorus, carbon disulphide, filter paper, phosphoric acid, ammonium hydroxide, powdered disodium hydrogen phosphate; magnesium sulphate, ammonium chloride, silver nitrate, and calcium chloride solutions.

Caution. — Ordinary, yellow phosphorus must be handled *only with tongs*, **never** with fingers! It must be kept and cut *under water*. No pieces of it must get into your locker; and every dish that has contained phosphorus must be *heated*, so that the phosphorus may be completely burned.

Do not bring carbon disulphide near a flame!

a. Put half a c.c. of red phosphorus into a test tube, and add 3 c.c. carbon disulphide. Result? Filter, and let the carbon disulphide evaporate, without heating, in a hood, or where its vapor will not get near a flame. Result? Was any phosphorus dissolved?

To 3 c.c. carbon disulphide add a piece of *yellow* phosphorus not larger than *a grain of wheat.* Shake carefully a few minutes. Result? Pour the solution, *every drop of it,* upon a piece of filter paper laid flat on a ring of the ring stand. Let the carbon disulphide evaporate with-

out heating it. Result? Rinse the test tube before putting it away.

b. Into a small ignition tube put a layer of red phosphorus not more than 5 mm. thick, hold tube horizontal (tongs), and *gently* heat end containing the phosphorus. What collects on the cold part of the tube? When the tube is cold, make a file-mark just below the deposit, and break the tube. Rub the deposit with a match stick. Result? Conclusion? *Finally,* heat both tubes red hot, so as to burn up all the phosphorus. Throw the pieces into iron or crockery jars.

c. To 5 c.c. water add 1 c.c. concentrated (ortho) phosphoric acid, *neutralize* in an evaporating dish (use litmus) with ammonia, and add silver nitrate solution. Result? The precipitate is *silver orthophosphate,* Ag_3PO_4. Write the two equations if the first product is $(NH_4)_2HPO_4$.

Dissolve 2 c.c. powdered *disodium hydrogen phosphate* in 10 c.c. water. To half of the solution add calcium chloride solution. Result? The product is *secondary calcium phosphate,* $CaHPO_4$. Equation?

d. To 5 c.c. *magnesium sulphate* solution add 1 c.c. ammonia-water and 1 c.c. ammonium chloride solution, and then the disodium hydrogen phosphate solution from *c.* Result? The product is *magnesium ammonium phosphate,* $NH_4MgPO_4.6\ H_2O$.

(1) $Na_2HPO_4 + NH_4OH \longrightarrow Na_2NH_4PO_4 + H_2O.$

(2) $Na_2NH_4PO_4 + MgSO_4 \longrightarrow MgNH_4PO_4\downarrow + Na_2SO_4.$

EXPERIMENT LV.

ARSENIC.

Apparatus. — Small ignition tube, tongs, test tube, beaker.

Materials. — Arsenic trioxide (powdered), charcoal, hydrochloric acid, hydrogen sulphide, ammonium sulphide, sodium hydroxide solution.

a. Into a small ignition tube put powdered *arsenic trioxide*, As_2O_3, to the depth of 5 mm. Hold the tube *horizontal* and at the *side* of the flame, so as to heat only the end containing the powder. What happens? Now slip into the tube, *almost* to the arsenic trioxide, a piece of charcoal about 2 cm. long. Heat the charcoal red hot (have tube horizontal), and then incline the tube slightly so as to heat the arsenic trioxide while keeping the charcoal red hot. Result? Effect of charcoal upon the oxide? Equation? How does the oxide come into contact with the charcoal? *Sublime* the arsenic obtained.

b. Heat half a c.c. of arsenic trioxide with 8 c.c. dilute hydrochloric acid to gentle boiling. Result? Equation? Pour off from any undissolved material, and pass in hydrogen sulphide for a minute. Result? If visible product is *arsenic trisulphide*, As_2S_3 (its color?), write equation. Let settle, pour off supernatant liquid, and add 5 c.c. *ammonium sulphide* to residue, shaking. Result? (CAUTION. — Do not get *ammonium sulphide on your hands!*) The product now formed is *ammonium sulpharsenite*, $(NH_4)_3AsS_3$; it is soluble. Treat solution

with an excess of dilute hydrochloric acid in a beaker. Result?

c. Treat half a c.c. of arsenic trioxide with sodium hydroxide solution. Warm carefully. Result? The solution contains *sodium arsenite,* Na_3AsO_3. From *b* and *c* would you say arsenic trioxide has *acid,* or *basic,* properties?

EXPERIMENT LVI.

ANTIMONY.

Apparatus. — Mortar and pestle, funnel, ignition tube.

Materials. — Antimony, concentrated nitric and hydrochloric acids, hydrogen sulphide, ammonium sulphide, antimony trioxide, tartar emetic.

a. What is the color of metallic antimony? Is it heavy or light? Powder a small piece, and treat part of it in a test tube with concentrated nitric acid. Results?

b. Treat the remainder of the powdered antimony of *a* with 3 c.c. concentrated hydrochloric acid and 1 c.c. concentrated nitric acid. Warm to start the action, if necessary. The solution contains *antimony chloride,* $SbCl_3$. Let action continue for ten minutes; then add 15 c.c. water. Filter, if necessary, and pass in hydrogen sulphide. If there is no action, dilute still more. Result? If the product has the formula Sb_2S_3, write the equation. Treat the antimony sulphide as you did arsenic trisulphide in Experiment LV, *b.*

c. Dissolve half a c.c. of *tartar emetic* in 5 c.c. water,

add a drop of hydrochloric acid, and pass in hydrogen sulphide. Result? Conclusion?

d. Heat antimony trioxide (Sb_2O_3) in an ignition tube with charcoal, as you did arsenic trioxide. Results?

EXPERIMENT LVII.

BISMUTH.

Apparatus. — Mortar and pestle, beaker, test tubes.

Materials. — Bismuth, concentrated nitric and hydrochloric acids, bismuth nitrate crystals, hydrogen sulphide.

a. What is the color of bismuth? Is the metal heavy or light? Malleable or brittle (test with the pestle)? Treat a bit with concentrated nitric acid. Result? Products?

b. To half a c.c. of bismuth nitrate crystals, $Bi(NO_3)_3$, add 5 c.c. water, and shake. Result? If the product has the formula $BiONO_3$, write the equation. Now add nitric acid (concentrated) a drop at a time, heating to boiling after each drop. Result? Use the least possible amount of acid.

c. Put half of the solution from *b* into a beaker, and add much water. Result? Compare with first part of *b*.

d. To the remainder of the acidified solution of bismuth nitrate from *b* add hydrogen sulphide. Result? The visible product is *bismuth sulphide,* Bi_2S_3. Write the equation.

EXPERIMENT LVIII.

BORAX AND BORIC ACID.

Apparatus. — Platinum wire sealed into glass rod, test tubes, beaker.

Materials. — Borax, potassium dichromate, manganese dioxide, hydrochloric acid, and sodium carbonate (solid).

a. **Borax Bead.** Make a loop 2 mm. in diameter on the end of a platinum wire sealed into a piece of glass tubing. Heat the loop to redness, and dip it into powdered borax, $Na_2B_4O_7 . 10\ H_2O$. Heat the adhering borax *just within* the outer edge of the Bunsen flame, at the place *where the flame is widest.* This is the **fusing zone** of the flame. What happens first? Heat until the borax melts to a *transparent* glass. If there is not enough borax to fill the loop, add more, and heat again. This glassy lump is called the **borax bead.**

b. Touch the hot bead to a tiny speck (less than half as large as a pin's head) of *potassium dichromate,* $K_2Cr_2O_7$, and heat at the top of the flame until the dichromate is completely absorbed by the bead. Color? Remove the bead by plunging it while hot into water, and wipe it off the wire.

c. Make a new bead, and touch it to a speck of manganese dioxide. Heat first in the **oxidizing flame** of the burner, *i. e.*, just above the *visible* tip of the flame. Color? Now heat it in the **reducing** region, *i. e.*, just *above* the tip of the *bright blue* interior cone. Heat it there persistently for five minutes, examining it from

time to time. Result? Heat it again in the oxidizing flame. Result?

d. **Boric Acid.**—Dissolve 5 grams powdered borax in 10 c.c. hot water, and add 10 c.c. concentrated hydrochloric acid. Set aside until next laboratory period. Result? The product is *boric acid*, H_3BO_3. Filter off the crystals, wash them on the filter with a little cold water, and dry them on fresh filter paper.

e. Dissolve the crystals of boric acid in hot water, and add the solution to a lump of sodium carbonate. Result?

EXPERIMENT LIX.

SODIUM COMPOUNDS.

Apparatus. — Test tubes, stopper and delivery tube, magnifying glass, platinum wire, watch glass or glass slip.

Materials. — Sodium bicarbonate, lime-water, sodium carbonate (solid and in solution), sodium chloride, calcium chloride, barium chloride, sodium nitrate and sulphate, hydrochloric acid.

a. Refer to Experiment XII for the properties of sodium and its action on water.

b. Heat 2 c.c. powdered sodium bicarbonate carefully in a test tube having a delivery tube that passes into lime-water. Result? Is there any other volatile product? When no more gas is evolved (do not melt the test tube), let the product in the tube cool, and then add 2 c.c. cold water. Note the temperature effect. Compare with this the action of anhydrous sodium carbonate

upon water. What are the products formed by heating sodium bicarbonate? Equation?

c. Heat 2 c.c. sodium chloride with 5 c.c. water in a test tube; filter; and let some of the filtrate evaporate completely on a glass slip or a watch glass. Examine the crystals with a magnifying glass, if possible. Their shape?

d. Dissolve a small piece of *calcium chloride*, $CaCl_2$, in 5 c.c. water, and add sodium carbonate solution. Result? Repeat, using *barium chloride* instead of calcium chloride. Result? Write the equations.

e. Dip a platinum wire with a glass holder (*cf.* Experiment LVIII, *a*) into 5 c.c. concentrated hydrochloric acid in a test tube, and then heat the wire in the Bunsen flame until the flame remains colorless. If necessary, dip the wire more than once. Now wet the clean wire with the acid, dip it into powdered sodium chloride, and heat it. Effect on the flame?

f. Clean the wire and repeat *e*, using sodium nitrate instead of sodium chloride. Repeat again with sodium sulphate. What color do sodium salts give to the flame?

EXPERIMENT LX.

POTASSIUM COMPOUNDS.

Apparatus. — Watch glass, iron dish, test tubes, beaker or evaporating dish, platinum wire, copper wire.

Materials. — Potassium chloride, sodium nitrate, sulphur, barium chloride solution, potassium hydrogen tartrate, lime-water, dilute sulphuric acid, concentrated hydrochloric acid, potassium nitrate, and potassium sulphate.

a. Heat 8 grams of potassium chloride and 10 grams of sodium nitrate with 20 grams of water until there is complete solution, and boil off half of the water over the wire gauze? Result? Let the precipitate settle and pour the solution into a test tube. Wash the residue with 5 c.c. cold water, and then dissolve it in the smallest possible amount of hot water. Pour a few drops of the solution in a watch glass and set aside. Result? Compare the crystals with those obtained in Experiment LIX, *c.* Conclusion?

What happens in the test tube containing the original solution? The visible product is *potassium nitrate,* KNO_3.

b. Mix 3 c.c. powdered potassium nitrate on a clean piece of paper with 1 c.c. powdered sulphur, and pour the mixture, *at arm's length,* upon a hot iron dish (use no wire gauze). Result? Let the product cool, boil it with 10 c.c. water in a test tube, and add to 5 c.c. of it *barium chloride* solution. Result? See Experiment XLIV, *b.* What is the product of the deflagration of potassium nitrate and sulphur?

c. Heat an iron dish red hot, and pour upon it 3 c.c. powdered *potassium hydrogen tartrate,* $KHC_4H_4O_6$ (cream of tartar). Results? Color of residue? Heat it five minutes longer at red heat, pressing the mass down with a glass rod occasionally. When the dish is cool, treat the residue in a test tube with dilute sulphuric acid. After all evolution of gas ceases, identify the gas by placing in the mouth of the tube a looped copper wire holding a drop of lime-water. What remains undissolved? What substance would you find in plant ashes if the plants contained potassium salts of organic acids?

d. Clean a platinum wire as in Experiment LIX, *e;* dip it into strong hydrochloric acid, and then into powdered potassium chloride, and heat it in the flame. Result? Repeat, using potassium nitrate instead of the chloride. Use the sulphate. Results? What color do potassium compounds give to the flame?

EXPERIMENT LXI.

AMMONIUM AMALGAM. DISTINCTIONS BETWEEN THE ALKALI METALS.

Materials. — Ammonium chloride, sodium amalgam, sodium and potassium chlorides, tartaric acid, two unknown substances.

a. Dissolve 2 c.c. ammonium chloride in 5 c.c. water, and add a piece of *sodium amalgam* (Na+Hg). Results? The product is *ammonium amalgam.* Note what happens to it. Odor? Reaction of solution?

Note. — Do not throw away the resulting mercury, but ask what to do with it.

b. Add 5 c.c. water to 3 c.c. powdered potassium chloride and shake thoroughly. Pour off the solution and add to it 5 c.c. of a *concentrated* solution of tartaric acid, $H_2C_4H_4O_6$. Make this by shaking 5 c.c. powdered tartaric acid with 15 c.c. water. Wait for result. Result? The product is *potassium hydrogen tartrate.* Equation?

c. Repeat *b,* using *sodium chloride* in place of potassium chloride. Result? Repeat again, using *ammonium chloride* in place of potassium chloride. Result?

d. From Experiment XXXIII, *b* and *c*, tell what happens when ammonium salts are treated with alkalies. How distinguish between *sodium* salts on the one hand and *ammonium* and *potassium* salts on the other? Between *sodium* salts and *potassium* salts (two ways)?

e. Get from the instructor two unknown substances, and determine if they are salts of sodium, potassium, or ammonium.

EXPERIMENT LXII.

CALCIUM.

Apparatus. — Triangle of iron wire, ring stand, blast-lamp, evaporating dish, platinum wire, and coin.

Materials. — Lumps of marble, lime-water, red litmus paper, old mortar, plaster of Paris, paper, calcium chloride, calcium sulphate, and ammonium carbonate solution.

a. Touch a piece of *wet* red litmus paper with a piece of marble. Result? Support a lump of marble about 5 c.c. in volume on a triangle of iron wire laid upon a ring of the ring stand, and heat the marble ten to fifteen minutes in the hottest Bunsen flame — in a blast-lamp, if possible. When the marble is cold, touch wet, red litmus with the part that was heated. Result? Explain. What products are formed when marble is heated (*cf.* Experiment XLVIII, *b*)?

Slake about 5 c.c. of quicklime by adding to it water, drop by drop, as long as the water is taken up *readily*. Wait for the result, and describe it. Is there a temperature effect? Equation?

b. To a piece of *old* mortar in a test tube add dilute hydrochloric acid. Identify the gas. What does fresh mortar absorb from the air?

c. Stir 10 c.c. plaster of Paris in an evaporating dish with enough water to form a fairly thick paste. Put the paste upon a piece of paper, and push into it a coin slightly coated with vaseline. At once wash the evaporating dish. Let the paste and coin stand an hour or more. Carefully remove the coin from the plaster. Result?

d. To a solution containing a calcium salt, *i. e.*, calcium *ions*, add *ammonium carbonate* solution. Result? See Experiment LIX, *d.*

e. Clean a platinum wire as in Experiment LIX, *e*, and determine what color *calcium chloride* gives to the flame. Repeat with *calcium sulphate.* Be sure to have concentrated hydrochloric acid upon the wire.

EXPERIMENT LXIII.

STRONTIUM AND BARIUM.

Apparatus. — Platinum wire and test tubes.

Materials. — Strontium chloride and nitrate, barium chloride and nitrate; solutions of strontium and barium chlorides; ammonium carbonate solution; dilute sulphuric acid.

a. Treat 2 c.c. *strontium chloride* solution with a few drops of ammonium carbonate solution. Result? Repeat, using *barium chloride* in place of strontium chloride. Write equations.

b. Treat 2 c.c. strontium chloride solution with dilute

sulphuric acid. Result? See Experiment XLIV, *a*. Equation?

c. Clean the platinum wire as in Experiment LIX, *e*, and heat a bit of strontium chloride in the flame. Repeat with *strontium nitrate*, $Sr(NO_3)_2$. Results?

d. Repeat *c*, using the corresponding barium salts. Results? How distinguish between calcium, strontium, and barium salts?

EXPERIMENT LXIV.

MAGNESIUM.

Apparatus. — Tongs, test tubes.

Materials. — Magnesium wire, dilute hydrochloric acid, solutions of magnesium sulphate and chloride, disodium hydrogen phosphate, and ammonium chloride and hydroxide, magnesite.

a. Hold a piece of magnesium wire 2 cm. long in the flame (use tongs). Result? Describe the product.

b. Treat a second piece of magnesium with dilute hydrochloric acid. Result? Identify the gas, and write the equation. See Experiment X.

c. To 2 c.c. of magnesium sulphate solution add sodium carbonate solution. Result? Repeat, using *magnesium chloride* instead of the sulphate.

d. See Experiment LIV, *d*, for the action of a solution containing a magnesium salt with disodium hydrogen phosphate and ammonium hydroxide. Rewrite the equations here.

Repeat that experiment with *magnesium chloride* solution instead of the sulphate. Equation?

e. Treat a small piece (half a c.c.) of magnesite with dilute nitric acid. Result? Identify the gas, and write the equation.

From Experiment XLVIII, *b*, tell the effect of heat upon magnesite.

EXPERIMENT LXV.

ZINC.

Apparatus. — File or sand-paper, knife, iron dish with flat bottom, test tubes, mouth blowpipe.

Materials. — Zinc, tin, lead, and copper; zinc dust; solutions of zinc sulphate, sodium hydroxide, and ammonium sulphide; dilute sulphuric and hydrochloric acids; hydrogen sulphide; stick of charcoal.

a. Clean part of a piece of zinc with a file or with sand-paper. Color? Is zinc hard or soft (use a knife or rough edge of glass)? Place a burner below the center of an iron dish. At equal distances from the center place pieces of zinc, tin, lead, and copper, and determine the order in which they *melt.* Return the metals to the proper bottles.

b. Heat a piece of zinc on charcoal with the *oxidizing flame and with the reducing flame* produced by the mouth blowpipe. Results? To do this proceed as follows: —

Hollow out a depression near one end of the charcoal, and into it put the zinc. To make the blowpipe flame, have a *luminous* Bunsen flame 4 cm. high, and hold the blowpipe so that the flame produced will be inclined about 30 degrees to the horizontal plane.

To make an **oxidizing** flame, hold the end of the blowpipe *inside* the luminous flame, a centimeter above the tip of the dark, inner cone. Hold the charcoal at such a distance that the zinc is in the outer, faintly-luminous part of the blowpipe flame.

To make a **reducing** flame, hold the tip of the blowpipe just at the *outer edge* of the flame at its middle part, and hold the *assay* (here, zinc) much nearer the blowpipe than in the oxidizing flame. The proper region is just at the tip of the *inner, light-blue* cone of the blowpipe flame.

c. What action has hydrochloric acid upon zinc? Equation? See Experiment VIII for the action of dilute sulphuric acid, and Experiment XVII for the behavior of *zinc sulphate* crystals, $ZnSO_4 . 7\ H_2O$, when heated.

d. Mix 1 c.c. zinc dust with 5 c.c. sodium hydroxide solution, and heat carefully. Test evolved gas with a flame. Result? The solution contains *sodium zincate*, Na_2ZnO_2. Write the equation.

e. To 2 c.c. zinc sulphate solution add a drop of sodium hydroxide solution. Result? What, probably, is the precipitate? Equation? Repeat with a second test tube. Now add to the first tube dilute hydrochloric acid, shaking. To the second tube add an *excess* of sodium hydroxide, shaking. Results? The alkaline solution contains sodium zincate. Equations?

What do these experiments show as to the nature of zinc hydroxide?

f. To 10 c.c. zinc sulphate solution add a drop of dilute sulphuric acid, and then hydrogen sulphide. Result? Put the solution into a beaker and add 5 c.c. *ammonium sulphide* solution, stirring. Result? The product is *zinc sulphide*, ZnS. Color? Equation?

Add 10 c.c. water, stir the mixture, let it settle, and then pour off the *supernatant* liquid. Add 15 c.c. more water, stir, let settle, and *decant*, i. e., pour off the water. This is called " washing by decantation."

To the zinc sulphide add dilute sulphuric acid. Result? What is the gas? Equation? Why was not zinc sulphide precipitated by hydrogen sulphide?

EXPERIMENT LXVI.

EQUIVALENT OF ZINC.

Apparatus. — Same as in Experiment X.

Materials. — Zinc, in sheet form or in sticks; dilute (5%) sulphuric acid.

a. Dissolve zinc in dilute sulphuric acid just as you did magnesium in Experiment X, and find the volume of hydrogen liberated by a known weight of zinc. Use from 0.45 gram to 0.55 gram of zinc. If the zinc is in sheet form, it will react readily; but a little impurity, chiefly carbon, will remain insoluble. If the zinc is *pure*, it will react with difficulty; therefore wind about the zinc a piece of platinum wire or a narrow strip of platinum foil. Set the apparatus aside until the zinc is in solution; then proceed as in Experiment X.

b. Reduce the volume of hydrogen to *standard conditions*, and calculate the *weight* of the hydrogen obtained. Finally, solve for x in the proportion, —

Wt. of zinc taken : Wt. of hydrogen obtained :: x: 1.

The value of x will be the **equivalent** of zinc.

EXPERIMENT LXVII.

CADMIUM.

Materials. — Cadmium sulphate, hydrogen sulphide, ammonium sulphide.

a. Dissolve completely not more than 1 c.c. *cadmium sulphate,* $CdSO_4$ in 5 c.c. water, and add hydrogen sulphide *in excess.* Result? The visible product is *cadmium sulphide,* CdS. Color? Equation? What other sulphides of the same color have you had? Wash the precipitate *by decantation,* and treat it with 5 c.c. ammonium sulphide. Result? How distinguish between cadmium sulphide and other sulphides of the same color?

EXPERIMENT LXVIII.

MERCURY.

Apparatus. — Pipette (medicine dropper).

Materials. — Mercury, concentrated nitric acid, hydrogen sulphide, hydrochloric acid, sodium hydroxide and potassium iodide solutions, ammonium hydroxide, zinc, and copper.

Caution. — Before working with mercury remove *all rings.* Do not throw mercury away; but ask what you are to do with it.

a. By means of a pipette take from the mercury bottle a globule three times as large as an ordinary water drop; add to it 2 c.c. water and 2 c.c. concentrated

nitric acid. Result? Let stand until action stops; this may take some hours.

b. While waiting for *a*, dissolve a globule of mercury the size of a water drop in concentrated nitric acid; this gives *mercuric nitrate*, $Hg(NO_3)_2$. Equation (*cf.* Experiment XXXVII, *g*)? Dilute with 15 c.c. water.

c. To 2 c.c. mercuric nitrate solution (*b*) add hydrogen sulphide. Result? The precipitate is *mercuric sulphide*, HgS. Equation?

d. Add to *separate* portions of the nitrate solution, **hydrochloric acid, sodium hydroxide** solution, and **potassium iodide** solution, *respectively*. Results? Add the potassium iodide *drop by drop*, noting changes. Write equations where possible.

Note. — With sodium hydroxide we should expect mercuric *hydroxide*, $Hg(OH)_2$; this, however, decomposes into the *oxide* and *water*.

e. Note the result of *a*. The crystals are *mercurous nitrate*, $HgNO_3$; pour out into a beaker, and add 15 c.c. water and a drop of strong nitric acid.

f. To 2 c.c. of the mercurous nitrate solution of *e* add *hydrogen sulphide*. The precipitate is *mercuric sulphide* and *mercury*. Write the equation.

g. Repeat *d* with the *mercurous* instead of the *mercuric* nitrate. Results? With sodium hydroxide the precipitate is *mercurous oxide*, Hg_2O. Write the equations. Treat the precipitate produced by hydrochloric acid with *ammonium hydroxide*. Result?

h. Into the rest of the mercurous nitrate put a strip of zinc and a copper wire. Results? Now rub them dry. Results?

i. Classify the results of *c*, *d*, *f*, and *g* in five vertical columns.

Formula of Precipitant.	Mercuric Nitrate.		Mercurous Nitrate.	
	Formula of Ppt.	Color.	Formula of Ppt.	Color.
NaOH, etc.				

EXPERIMENT LXIX.

COPPER.

Apparatus. — File or sand-paper.

Materials. — Copper wire, concentrated hydrochloric acid; solutions of cupric sulphate, ammonium hydroxide, sodium hydroxide, and cupric nitrate; grape-sugar; iron nail.

a. File a piece of copper bright. Color? Is it hard or soft? From Experiment LXV give its *fusibility* compared with zinc, etc. By holding one end of the wire in the flame determine if it is a conductor of heat.

b. From Experiments XXXVII and XLII tell the action of nitric and sulphuric acids upon copper. Find out if copper reacts readily with concentrated hydrochloric acid.

c. To 2 c.c. cupric sulphate solution add *ammonium hydroxide* solution in excess. Result? Repeat with *sodium hydroxide* instead of ammonium hydroxide.

Result? Repeat, having the cupric sulphate *hot*, and then add the sodium hydroxide. Result? The last precipitate is *cupric oxide*, CuO. How formed (*cf.* Experiment LXVIII, *d* and *g*)?

d. From Experiment XLI, *b* and *c*, tell the effect of hydrogen sulphide upon cupric sulphate. Equation? Pass hydrogen sulphide into cupric nitrate solution. Result? Equation? What is the effect of heating *blue vitriol* (*cf.* Experiment XVII, *d*)?

e. Dissolve half a c.c. powdered *grape-sugar*, $C_6H_{12}O_6$, in 2 c.c. water, and add it to 5 c.c. cupric sulphate solution. Now add sodium hydroxide solution, shaking until the precipitate first formed is redissolved. Color? Warm carefully, noting changes. Let stand. Results? Color of product? It is *cuprous oxide*, Cu_2O. What effect had the grape-sugar?

f. Put an iron nail into cupric sulphate solution. Result?

EXPERIMENT LXX.

SILVER.

Materials. — Silver foil, silver nitrate solution, nitric acid, sodium thiosulphate; solutions of sodium chloride and potassium bromide, iodide, and cyanide; filter paper; hydrogen sulphide.

a. In a test tube treat a piece of silver foil with 2 c.c. concentrated nitric acid. Result? Equation? Dilute with water to 10 c.c.

b. To 2 c.c. of the solution of *a* add 5 c.c. sodium chloride solution. Result? Equation (*cf.* Experiment

XXII, *j*)? Boil the contents of the tube. Result? Get the precipitate on filter paper, and expose it to sunlight. Result?

c. To 5 c.c. of solution *a* add 1 c.c. potassium bromide solution. Result? Heat to boiling, pour off the supernatant liquid, and add to half of the precipitate *sodium thiosulphate* solution, $Na_2S_2O_3$ (make this by dissolving the crystals in water). Result? Expose the other half on filter paper to sunlight. Result?

d. To 1 c.c. silver nitrate solution add 1 c.c. *potassium iodide* solution. Result? Equation?

e. To 1 c.c. silver nitrate solution add hydrogen sulphide. Result? Equation?

f. To 1 c.c. silver nitrate solution add *potassium cyanide* solution, drop by drop. Result. Equation? Continue adding it, shaking, until it is in excess. Result? The solution contains the *double cyanide*, KCN.AgCN, *i. e.*, $KAg(CN)_2$. Add sodium chloride solution. Result? Explain the result in terms of the ionic theory (*cf.* Experiment XXX).

EXPERIMENT LXXI.

ALUMINUM.

Apparatus. — Test tubes, tongs, blast-lamp.

Materials. — Aluminum wire and filings, white muslin, hydrochloric acid; solutions of sodium hydroxide, aluminum sulphate, sodium carbonate, alum, ammonium hydroxide, and cochineal; powdered alum, sodium bicarbonate, potassium sulphate, ammonium sulphate, aluminum sulphate.

a. Determine whether aluminum is a conductor of heat as in Experiment LXIX, *a.* Does the wire melt in the Bunsen flame (use tongs)? Try the blast-lamp. Result?

b. To 2 c.c. aluminum filings add 5 c.c. concentrated hydrochloric acid, and warm. Result? Test the gas. Equation?

c. Wash the filings remaining from *b*, by decantation, add 5 c.c. concentrated sodium hydroxide solution, and warm carefully. Determine the nature of the gas evolved. Result? The solution contains *sodium aluminate*, Na_3AlO_3 (*cf.* Experiment LXV, *d*). Equation?

d. To 5 c.c. of *aluminum sulphate* solution, $Al_2(SO_4)_3$, add 1 c.c. sodium hydroxide solution. Result? Equation? Get half of the precipitate into a second test tube, and add an excess of sodium hydroxide solution. Result? If the solution now contains sodium aluminate, Na_3AlO_3, write the equation. To the other half of the precipitate add hydrochloric acid. Result? Equation? Compare with this the behavior of *zinc hydroxide.*

e. Dissolve as much *ammonium sulphate* as possible in 5 c.c. hot water, and add to it in a beaker 5 c.c. water similarly saturated with *aluminum sulphate.* Cool the mixture. Result? The product is *ammonium alum.* Heat again to complete solution, and let stand over night. Result? Shape of crystals?

f. Repeat *e*, using *potassium sulphate* instead of ammonium sulphate. Results? Compare the crystals.

g. To 5 c.c. of the solution of any aluminum salt add *sodium carbonate* solution. Result? Identify the escaping gas. The precipitate is *aluminum hydroxide,* $Al(OH)_3$. Mix a cubic centimeter of powdered alum

with a cubic centimeter of sodium bicarbonate, and add water. Result?

h. To 1 c.c. of a solution of cochineal add 5 c.c. alum solution, immerse a piece of white muslin, and then add ammonium hydroxide solution, shaking. Results?

EXPERIMENT LXXII.

IRON.

Apparatus. — Test tubes, tongs, blast-lamp, magnet, beaker.

Materials. — Iron wire and filings, copper wire; hydrochloric, sulphuric, and nitric acids; solutions of potassium ferrocyanide, ferricyanide, and sulphocyanate; ammonia water, hydrogen sulphide, ammonium sulphide, solid ferrous sulphate, and ferric chloride.

a. Compare the heat conductivity of iron wire with that of copper. Test its magnetic properties; its fusibility in the Bunsen flame and the blast-lamp. Results?

b. Treat 3 c.c. iron filings in a beaker with 20 c.c. dilute hydrochloric acid, stirring. Results? Identify the gas. If the solution contains *ferrous chloride*, $FeCl_2$, write the equation. When action almost ceases, filter off 10 c.c. of the solution. Color of filtrate?

c. Divide the filtrate of *b* into *four* parts. To the *first* add a few drops of *potassium ferricyanide* solution, $K_3Fe(CN)_6$. Result? This is "*Turnbull's blue.*" To the *second* portion add ammonia-water. Result. Equation? Note any change on standing in the air. To the *third* part add *potassium ferrocyanide*, $K_4Fe(CN)_6$.

Result? To the last portion add *potassium sulphocyanate* solution, KSCN. Result?

Wash out your test tubes and beakers at once.

d. Filter the remainder of the ferrous chloride solution of *b*, and add 2 c.c. concentrated nitric acid. Heat carefully for two minutes in a beaker. Resulting color? The solution contains *ferric* chloride and nitrate. To a drop of it in a test tube add a drop of potassium ferricyanide solution; if it still gives a blue precipitate, add 2 c.c. more nitric acid, and boil again.

Treat the resulting substance in *four* test tubes with the reagents used in *c*. Result in each case?

The precipitate from potassium ferrocyanide and a ferric salt is **"Prussian blue."**

e. Classify the results of *c* and *d* (last part) in five vertical columns.

Formula of Reagent.	Ferrous Chloride.		Ferric Chloride.	
	Precipitate or Solution?	Color.	Precipitate or Solution?	Color.

f. In a test tube shake 2 c.c. powdered *ferrous sulphate* with 10 c.c. water, pour off half of the solution, and pass hydrogen sulphide into it. Result? Does all the iron appear to be precipitated? Write the equation representing the reaction you would expect to take place.

From Experiment XLI tell the effect of dilute sulphuric acid upon ferrous sulphide. Write the equation here. Compare these two equations. Conclusion?

To the other half of the ferrous sulphate solution add five drops of dilute sulphuric acid, and pass in *hydrogen sulphide*. Compare with the result without the acid. Now add *ammonium sulphide*. Result? Equation?

g. Dissolve 1 c.c. *ferric chloride*, $FeCl_3$, in 10 c.c. water, and pass in hydrogen sulphide at least *two* minutes. Result? Boil the contents of the tube, and then filter. Test the filtrate with a drop of potassium ferricyanide solution. Result and conclusion?

Determine the nature of the residue on the filter paper by collecting it on a piece of porcelain and igniting it. Odor?

Write the equation for the action of hydrogen sulphide on ferric chloride.

EXPERIMENT LXXIII.

NICKEL AND COBALT.

Apparatus. — Platinum wire, test tubes.

Materials. — Nickel and cobalt and their nitrates; *solutions* of the nitrates; borax, sodium hydroxide solution, concentrated, chemically pure hydrochloric acid.

a. Give the physical properties of cobalt and nickel from an examination of the metals. Effect of a magnet?

b. To 2 c.c. *nickel nitrate* solution, $Ni(NO_3)_2$, add a drop of hydrochloric acid and then hydrogen sulphide. Result? Now add *ammonium sulphide*. Result? Equation? Explain the results from Experiments XLI and LXXII, *f*.

c. Make a borax bead as in Experiment LVIII, *a* and *b*, and determine the color given to it by nickel nitrate.

d. Repeat *b* and *c* with *cobalt nitrate*, $Co(NO_3)_2$, instead of nickel nitrate. Results?

e. To 2 c.c. cobalt nitrate solution add sodium hydroxide solution, a drop at a time, until it is in excess. Results?

f. To 2 c.c. cobalt nitrate solution add 5 c.c. concentrated, chemically pure hydrochloric acid. Result? Dilute with water. Result?

EXPERIMENT LXXIV.

MANGANESE COMPOUNDS.

Apparatus. — Platinum wire, test tubes.

Materials. — Manganese sulphate, potassium permanganate, ferrous sulphate, grape-sugar, ammonia-water, hydrogen sulphide, and ammonium sulphide.

a. Dissolve 1 c.c. powdered *manganese sulphate*, $MnSO_4$, in 5 c.c. water. To *half* of it add a drop of dilute sulphuric acid and then hydrogen sulphide. Result? Now add *ammonium sulphide.* Result? Color? Equation? Explain the results.

b. To the other half of solution *a* add ammonia-water. Result? Equation?

c. To 2 c.c. ferrous sulphate solution (*cf.* Experiment LXXII, *f*) add potassium permanganate solution. Result? Continue, drop by drop, until the solution is just *faintly* pink. Now add ammonia-water. State and explain the result (*cf.* Experiment XLII, *f*).

d. Dissolve a crystal of *potassium permanganate*, $KMnO_4$, in water, and add grape-sugar solution. Result? Explain (*cf.* Experiment LXIX, *e*).

e. From Experiment XXI tell the action of *manganese dioxide* with hydrochloric acid; from Experiment V, with *potassium chlorate;* from Experiment LIII, with *hydrogen peroxide;* and from Experiment LVIII, *a*, tell the color of the *manganese bead.*

EXPERIMENT LXXV.

CHROMIUM COMPOUNDS.

Apparatus. — Chlorine generator, platinum wire, evaporating dish, test tubes.

Materials. — Solutions of potassium chromate and dichromate, of chromic chloride, of potassium and sodium hydroxides; hydrochloric acid, alcohol, borax, barium chloride solution, chrome-alum.

a. What is the color of solutions of *potassium dichromate* ($K_2Cr_2O_7$), *potassium chromate* (K_2CrO_4), and of *chromic chloride* ($CrCl_3$)?

b. Treat 1 c.c. of *potassium dichromate* solution with a drop of potassium hydroxide solution. Result? From the color tell what is formed.

Complete the equation,

$$K_2Cr_2O_7 + 2\ KOH \longrightarrow ? + ?$$

c. To 1 c.c. *potassium chromate* solution add a drop of concentrated hydrochloric acid. Result? What is formed?

$$2\ K_2CrO_4 + 2\ HCl \longrightarrow ? + ? + ?$$

How can a dichromate be changed to a chromate? A chromate to a dichromate?

d. To 2 c.c. potassium chromate solution add barium chloride solution. Result? Equation? Repeat with *chromic chloride* instead of the chromate. Result?

e. To 1 c.c. chromic chloride solution add a drop of sodium hydroxide solution. Result? Equation? Now add the alkali *in excess*, shaking. Result? The solution contains a *chromite*, $NaCrO_2$. What other elements behave in this way? See Experiments LXV and LXXI. Save for *g*.

f. Repeat *e* with potassium chromate instead of *chromic chloride*. Result? In what three ways can a chromic salt be distinguished from a chromate?

g. To the clear solution of *e* add *chlorine* gas until there is no further change. Do this in a gas-chamber. Results? Test the resulting solution as in *b*, *c*, and *d*. Results? How can a chromic salt be changed into a chromate?

h. To 10 c.c. potassium dichromate solution in an evaporating dish add 2 c.c. concentrated hydrochloric acid and 2 c.c. ethyl alcohol. Boil until *bright* green, but not to dryness. Test a part of the liquid with barium chloride solution. Result? With potassium hydroxide solution. What does the green solution contain? How can a chromate be changed to a chromic salt? See, also, Experiment XLII, *f*.

i. Refer to Experiment LVIII for the borax bead test. Repeat with a tiny piece of *chrome-alum*. Result?

EXPERIMENT LXXVI.

LEAD.

Apparatus. — File or knife, test tubes, mouth blowpipe.

Materials. — Lead; hydrochloric, nitric, and sulphuric acids; lead nitrate, solutions of potassium chromate and sodium hydroxide, lead oxide, stick of charcoal.

a. File or cut off the coating on lead. Is it hard or soft? Color? Try to mark on paper with lead. Result? Refer to Experiment LXV, *a*, for its fusibility. Treat a small piece with hydrochloric acid, both the dilute and the strong. Results? Wash the lead, and add 2 c.c. concentrated nitric acid and 2 c.c. water. Heat gently. Result? Write the equation (*cf.* Experiment XXXVII).

b. Heat one-fourth of a c.c. of *lead monoxide* on charcoal in the *reducing* flame (mouth blowpipe). See Experiment LXV, *b*. Result? How identify the product?

c. Dissolve 2 c.c. powdered *lead nitrate*, $Pb(NO_3)_2$, in 15 c.c. water, heating. Cool, and add to 2 c.c. of the solution 5 c.c. dilute hydrochloric acid. Result? Equation? Wash the precipitate by decantation, and heat it with 10 c.c. water. Result? Cool the solution. Result?

d. To 2 c.c. of the lead nitrate solution add dilute sulphuric acid. Result? Use *potassium chromate* solution instead of sulphuric acid. Result? Equation in each case?

From Experiment XLI, *d*, tell effect of *hydrogen sul-*

phide upon lead nitrate. For the reduction of *lead oxide* by charcoal, see Experiment XLVIII, *a*.

e. To 2 c.c. lead nitrate solution add a drop of *sodium hydroxide* solution. Result? Equation? Now add an excess, shaking. Result? What *three* other hydroxides behave in the same way? See Experiment LXXV, *e*.

f. Put into the remainder of the lead nitrate solution a strip of zinc. Leave it *at least* ten minutes. Result? Equation (*cf*. Experiment LXIX, *f*)?

EXPERIMENT LXXVII.

TIN.

Apparatus. — Test tubes, stopper and delivery tube, mouth blowpipe.

Materials. — Tin (granular and in a bar); concentrated hydrochloric and nitric acids; solutions of mercuric chloride, stannic chloride, and sodium hydroxide; ammonium sulphide, hydrogen sulphide, zinc, sulphur, stick of charcoal.

a. Treat about 2 c.c. of small bits of tin with 10 c.c. concentrated hydrochloric acid in a test tube. Warm gently to start the action, and when the effervescence is vigorous attach a stopper and delivery tube and collect the gas over water. Identify the gas. Result? The solution contains *stannous chloride*, $SnCl_2$. Equation? Let the action continue at least ten minutes.

b. From Experiment LXV, *a*, compare the fusibility of tin with that of lead, etc. Hold a bar of tin near your ear, and bend it. Result? What color has bright tin? Is it hard or soft?

c. To 1 c.c. *mercuric chloride* solution, $HgCl_2$, add 4 or 5 c.c. of your stannous chloride solution, and then heat. Note all the changes. The solution contains *stannic chloride*, $SnCl_4$. Equation?

d. To 2 c.c. stannous chloride solution add 5 c.c. water and then hydrogen sulphide. Result? Color? Equation? Wash the precipitate by decantation, and add 5 c.c. *ammonium sulphide* (use an evaporating dish or beaker) and a small lump of sulphur. Warm gently, and stir. Result? Cool, and add dilute hydrochloric acid in excess. Result? Compare the color with that of the original precipitate.

e. To 2 c.c. stannous chloride solution add 1 c.c. concentrated nitric acid, and heat gently. The solution contains *stannic* chloride. Dilute with 5 c.c. water, and pass in hydrogen sulphide. Result? Color? Stannic sulphide is SnS_2. Equation? Wash the precipitate by decantation, add ammonium sulphide and a bit of sulphur, and warm gently. Result? Add an excess of dilute hydrochloric acid. Result? Compare with the color of the original precipitate, and with that obtained at the end of *d*. Conclusion?

f. To 2 c.c. stannic chloride solution add sodium hydroxide solution, drop by drop. Result? Add an excess. Result? What other hydroxides have behaved in the same way? See Experiment LXXVI, *e*.

g. Pour the solution of *a* from any unused tin, and put into it a strip of zinc. Result? Equation? Compare with Experiment LXXVI, *f*.

h. Heat a piece of tin on charcoal in the *oxidizing flame* (mouth blowpipe). See Experiment LXV, *b*. Results?

EXPERIMENT LXXVIII.

COMPOSITION OF CARBON COMPOUNDS.

Apparatus. — Iron dish (sand bath), test tubes, stopper and delivery tube, ignition tube, rubber connector.

Materials. — Sugar, starch, oxalic acid, benzoic acid, powdered cupric oxide, lime-water, gelatine (powdered), soda-lime, urea, litmus.

a. In an iron dish (sand bath) heat one cubic centimeter of *sugar* as long as a change occurs. Repeat with *starch;* with a crystal of *oxalic acid.* Results? What proof have you that the sugar and starch contain carbon? The oxalic acid?

b. Heat half a c.c. of oxalic acid crystals in a test tube. Determine whether carbon dioxide is evolved or not. Results? Heat half a c.c. of *benzoic acid* in a test tube. Result? Is there any evidence of carbon dioxide?

Recall Experiment XLVIII, *a.* Repeat it, using one-fourth of a c.c. of benzoic acid and five times its volume of powdered cupric oxide instead of the charcoal and lead oxide. Results? Is there any evidence that hydrogen was present in the benzoic acid? What precaution is necessary to be *certain,* if it is known that the cupric oxide used is slightly hygroscopic?

c. Recall Experiment XXXIII, *a.* Repeat it, using powdered *gelatine* in place of the glue, and powdered *soda-lime* instead of slaked lime. Results? Repeat it again with *urea* in place of the gelatine. Conclusions? If glue and gelatine represent the class of *albumins,* what element must the members of this class contain?

EXPERIMENT LXXIX.

HYDROCARBONS.

Apparatus. — Mortar and pestle, ignition tube 15 cm. long, ring stand, clamp, delivery tube, rubber connector, test tubes, 100 c.c. flask, wire gauze, one-hole stopper, pneumatic trough, evaporating dish.

Materials. — Dry soda-lime and *fused* sodium acetate, lime-water, bromine water, concentrated sulphuric acid, "95 per cent" ethyl alcohol, calcium carbide, benzene.

a. **Methane.** — In a mortar powder and mix 2 grams of soda-lime and 1 gram of dry, fused sodium acetate. With the mixture half fill an ignition tube 15 cm. long, and attach a delivery tube by means of a rubber connector. Support the tube horizontally, tap it to insure a passage for gas, and heat it with a moving flame. Collect the evolved gas — it is impure *methane* (*cf.* § 292) — in three test tubes. Note its physical properties and combustibility. After burning a test tube of the gas, pour lime-water into the tube, close it with the thumb, and shake it. Result? Conclusion? To one test tube of methane add a drop of bromine water. Close the tube, and shake it. Does the color of the bromine disappear?

b. **Ethylene.** — In a 100 c.c. flask *cautiously* add 10 c.c. of concentrated sulphuric acid to 5 c.c. of alcohol. Shake the flask after each addition of acid so as to insure mixing. Support the flask *over* wire gauze but not quite touching it, and attach a stopper and a delivery tube with a rubber connector. *Do not leave the delivery tube in the*

water when you stop heating! Heat with a small flame until a regular stream of gas comes off, and collect three test tubes full over water. Note its physical properties and the character of its flame. Test with lime-water and bromine water as in *a*. Results?

c. **Acetylene.** — In a test tube mix 2 c.c. — *no more* — of water with 5 c.c. of alcohol. Add two pieces of *calcium carbide* the size of peas, and at once attach a stopper and delivery tube. Collect the evolved gas (acetylene) over water in three test tubes. Note its properties as directed in *a* and *b*. *Do not inhale it.*

d. **Benzene.** — Put half a cubic centimeter — no more — of *benzene*, C_6H_6, in an evaporating dish. Note its odor. Carefully ignite the benzene. Describe its flame. Write the equation for the combustion of benzene, if the products are carbon dioxide and water.

EXPERIMENT LXXX.

ETHYL ALCOHOL.

Apparatus. — Flask (100 c.c.), stopper and delivery tube, test tubes, evaporating dish, distilling apparatus.

Materials. — Molasses (or powdered grape sugar), yeast, lime-water (or baryta water), litmus, sodium bicarbonate, alcohol, powdered shellac or rosin.

a. To 25 c.c. water in a 100 c.c. flask add 5 c.c. molasses or powdered grape sugar and about one cubic centimeter of compressed yeast. Attach tightly a stopper with a delivery tube, and let the tube pass into 5 c.c. lime-water or baryta water in a test tube. Let the

flask stand in a warm place, and note results. If you leave the delivery tube in the lime-water over night, see that it dips only slightly below the upper surface of the liquid. Why? If the test tube contains no precipitate the next day, heat its contents to boiling. Explain the result. Test the reaction of the solution in the flask toward litmus. Result?

b. Ask the teacher to collect from several students the dilute alcohol they have prepared, and to distill it, if this was not done in connection with § 280. If the first portions of the distillate do not burn when a flame is applied they must be *redistilled.* The first few drops may then be tested for alcohol.

c. Set some of the fermented solution aside, without stoppering the flask, for a week or two. Then note the taste of the solution, its reaction to litmus and its effect upon a little solid sodium bicarbonate in a test tube. Results?

d. Put two or three drops of alcohol into an evaporating dish, warm the dish slightly, and apply a flame. Note the color of the alcohol flame. Write the equation for its combustion.

e. Treat half a cubic centimeter of powdered shellac or rosin in a test tube, with 5 c.c. alcohol. Close the tube with the thumb, and shake it. Result? Add 5 c.c. water. Result? Let the tube stand until the next period. Result?

EXPERIMENT LXXXI.

ETHYL ETHER.

Apparatus. — Evaporating dish, test tubes.
Materials. — Ethyl ether, paraffin.

Caution. — *Do not bring the bottle of ether near a flame!*

a. Put two drops of ether into an evaporating dish, remove the ether bottle, and apply a flame to the ether in the evaporating dish. Describe the flame.

b. In a test tube add 2 c.c. ether to a piece of paraffin half the size of a pea, shaking. Result? Pour the ether out into the evaporating dish, and hold the dish in the hand to drive off the ether. Result? Note the volatility and odor of the ether.

EXPERIMENT LXXXII.

ALDEHYDES.

Apparatus. — Test tubes, stirring rod, ring stand or rack, tongs.
Materials. — Granular potassium dichromate, concentrated sulphuric acid, methyl alcohol, ethyl alcohol; solutions of silver nitrate, caustic soda, and ammonia; copper wire for spiral.

a. In a test tube add 2 c.c. of concentrated sulphuric acid to 6 c.c. of water, cool the mixture under the tap, and add 2 c.c. of alcohol. Pour this mixture upon 2 c.c. of granular potassium dichromate in a test tube.

Hold the test tube over the sink. Results? Note the odor of the escaping vapors of *acetaldehyde*, CH_3CHO. Hold in the vapors a stirring rod wet with *ammoniacal* silver nitrate solution. To make this, add one drop of a 10 per cent solution of caustic soda to 1 c.c. of silver nitrate solution, and then add 1 c.c. of ammonia water. The deposit on the rod is silver. Explain.

b. Put 2 c.c. of *methyl alcohol*, CH_3OH, in a test tube supported in a ring stand or rack. Make a copper spiral by winding about a glass rod or a pencil a foot of copper wire. Remove the pencil or rod, and hold the spiral in the flame (use tongs) until it is red hot. Then drop it into the methyl alcohol. Note the sharp vapor of *formaldehyde*, CH_2O, mixed with the vapor of the alcohol.

$$CH_3OH + O \longrightarrow CH_2O + H_2O.$$

EXPERIMENT LXXXIII.

ACETIC ACID AND ACETATES.

Apparatus. — Beaker (50 c.c.), test tubes, evaporating dish, stirring rod, wire gauze, ring stand.

Materials. — Commercial (concentrated and dilute) acetic acid, concentrated sulphuric acid, vinegar, sodium carbonate, litmus and filter papers, alcohol.

a. Note the taste of a drop of *dilute* acetic acid. Heat some to boiling in a test tube. Odor? Its action to litmus? *Cf.* Experiment XXIV, *a* and *b*. Test vinegar in the same ways. Results?

b. In a test tube mix 1 c.c. of concentrated acetic acid with 2 c.c. of alcohol, and add half a c.c. of concen-

trated sulphuric acid. Heat carefully, and describe the odor. It is that of *ethyl acetate*, $CH_3COOC_2H_5$. The sulphuric acid removes water. Equation? If you were given a liquid suspected of being acetic acid, how would you prove it to be this substance?

c. In a 50 c.c. beaker dissolve 10 grams of sodium carbonate in 10 c.c. of water and add to it commercial acetic acid (5 c.c., or less, at a time) until the reaction is distinctly acid on stirring, and effervescence ceases. Then transfer the solution to an evaporating dish, and concentrate it over the wire gauze until a drop held on a stirring rod crystallizes when cool (*cf.* Experiment XXXVII, *g*). Set the dish aside until the next period. Name the crystals. Their shape? Filter them off, and dry them between filter papers.

d. Carefully heat some of the crystals of *c* in a test tube. Do they contain crystal water (*cf.* Experiment XVII)? Treat 1 c.c. of them, in a test tube, with 1 c.c. of concentrated sulphuric acid, and warm gently. Result? Odor? Remember to pour the concentrated acid *into* water when cleaning the test tube!

To 1 c.c. of the crystals add 1 c.c. alcohol and half a c.c. of concentrated sulphuric acid. Warm gently, and note the odor of the vapors. Result? Conclusion?

EXPERIMENT LXXXIV.

OTHER ORGANIC ACIDS.

Materials. — Citric acid, lemon juice, oxalic acid, benzoic acid, alcohol, sodium bicarbonate, potassium permanganate solution, dilute and concentrated sulphuric acid, litmus.

a. For the properties of *tartaric acid* see Experiments XXIV, *c;* XLVII, *a;* LX, *c;* and LXI, *b* and *c.*

b. Make an aqueous solution (by heating) of 1 gram, or less, of crystallized *citric acid,* $H_3C_6H_5O_7+H_2O$, and note its taste, odor, and reaction toward litmus and toward sodium bicarbonate. Repeat, using *lemon juice* instead of citric acid solution. Results?

c. See Experiment LXXVIII for the behavior of *oxalic acid,* $H_2C_2O_4$, when heated. Prove the presence of crystal water in oxalic acid. To 1 c.c. of potassium permanganate solution add half a c.c. of dilute sulphuric acid and then oxalic acid solution, drop by drop. Result? Conclusion?

d. Heat 1 c.c. of *benzoic acid,* C_6H_5COOH, with 5 c.c. of water. Result? Boil for a moment. Odor of vapors? Now cool the solution under the faucet. Result? Redissolve the benzoic acid by applying heat. Cautiously taste a drop of the solution, and note its action toward litmus and sodium bicarbonate. Results?

In a test tube heat carefully 1 c.c. of benzoic acid with 1 c.c. of alcohol until you get a solution; then add half a c.c. of concentrated sulphuric acid and heat again. Note the odor of the vapors of *ethyl benzoate,* $C_6H_5COOC_2H_5$. Pour the solution into 10 c.c. water, and note the separation of the oily ester.

EXPERIMENT LXXXV.

SOAP.

Apparatus. — "Tin" can, stirring rod, test tubes, ring stand.

Materials. — Sodium hydroxide, lard, fine salt, "Castile" or "Ivory" soap, litmus, dilute sulphuric acid, calcium sulphate solution.

a. In a clean "tin" can dissolve 8 grams of sodium hydroxide in 60 c.c. cold water. If possible have the cover only partially cut out, so that it may be pushed down as a lid during the boiling. To the alkaline solution add 25 grams of *lard*, and heat the mixture to boiling, having the opening of the can almost closed by the lid. *Be careful not to let the alkali spatter into your eyes!*

After thirty minutes *stop the boiling*, and see if the mixture begins to become solid. (Care!) If not, continue heating until it does.

Now add to the mixture, while it is still warm, 16 grams of fine salt in lots of about 2 grams each. Stir *carefully* after each addition. Finally, boil the mixture for ten minutes, and let it cool. The soap will appear as a solid cake on the surface of the solution. Remove it, rinse it with a little water, and let it dry.

b. Dissolve about 1 c.c. of "Ivory" or "Castile" soap in 10 c.c. of water, and test the reaction of the solution with litmus. Result? Treat half of the solution with dilute sulphuric acid. Result? The solid product is a mixture of the organic acids of the soap.

Treat the other half of the soap solution with a solution of calcium sulphate. Result? Heat to boiling. The product is the calcium salt of the acids ("lime soap"). (*Cf.* §§ 70, 413, and 435 of text.)

EXPERIMENT LXXXVI.

CARBOHYDRATES.

Apparatus. — Beaker, test tubes, ring stand, wire gauze.

Materials. — Fehling's solution (see *a*), grape sugar, cane sugar, molasses, concentrated hydrochloric acid, sodium carbonate, starch or starch paste.

a. See Experiment LXIX for the action of grape sugar with alkaline cupric salts. A better solution for testing the sugars is the one called **"Fehling's Solution."** Cupric sulphate crystals (34.64 grams) and 1 c.c. dilute sulphuric acid are dissolved in water, and the solution is diluted to exactly 500 c.c. This is solution I. Solution II consists of 175 grams of sodium potassium tartrate, 50 grams of sodium hydroxide, and enough water to make the volume exactly 500 c.c. These solutions are kept in separate, rubber-stoppered bottles. Equal volumes of the two are mixed just before they are used. One cubic centimeter of Fehling's solution is completely reduced by exactly 0.005 gram of grape sugar.

To 10 c.c. Fehling's solution in a beaker add a drop of a solution of grape sugar, and heat to boiling over the wire gauze. Result? Let the precipitate settle, and add another drop of grape sugar solution; repeat the process until the Fehling's solution has just lost its blue color. Calculate how much grape sugar you added.

b. In a test tube add some cane sugar solution to 5 c.c. Fehling's solution, and heat to boiling. Is there reduction? Try a solution of molasses instead of cane sugar. Result?

c. To 20 c.c. cane sugar solution in a beaker add 2 c.c. of concentrated hydrochloric acid, and heat gently to boiling for fifteen minutes over the wire gauze. Cool, and neutralize the acid with solid sodium carbonate; then test with Fehling's solution. Result?

d. Repeat *b* and *c*, using 20 c.c. starch solution (make it as in Experiment LI, *d*) instead of cane sugar. Results?

EXPERIMENT LXXXVII.

SOME PRINCIPLES OF QUALITATIVE ANALYSIS.

Apparatus. — Funnel, funnel support, beaker, test tubes.

Materials. — Solutions of nitrates of iron (ferric), silver, copper, barium, and sodium; hydrochloric acid, hydrogen sulphide, dilute sulphuric acid, ammonia water, filter papers, and two or more " unknown " substances.

a. Qualitative Analysis is a system of experiments for the separation and identification of the elements present in mixtures of substances. In a limited sense the term is applied to the detection of the ordinary metals and acids. The separation of metals present as *ions* in a solution is possible if we can convert some of the metals into insoluble compounds while leaving the others in solution. The following experiments show how a scheme of analysis may be devised for the separation of the five metals: *silver*, *copper*, *iron*, *barium*, and *sodium*. We use solutions of the *nitrates*, since these are all soluble. Make *ferric nitrate*, if this is not found in the laboratory, by covering about 1 gram of iron wire or filings with 10 c.c. of water in a beaker and adding 10

c.c. dilute nitric acid in small portions. When action ceases, filter the solution and dilute it to 60 c.c.

b. To 5 c.c. of each of the nitrates named in *a* add dilute *hydrochloric acid* — one cubic centimeter at a time — until there is an *excess*. To know if you have an excess of the precipitant let the precipitate settle, and add a drop more of the precipitant to the clear solution; or filter a little of the precipitated solution and test the filtrate in the same way. (*Cf.* § 246, *last two paragraphs.*) Be sure that your test tubes are clean for every test.

Copy the following table in your note book, and put down the results in their places.

Effect of	$AgNO_3$	$Cu(NO_3)_2$	$Fe(NO_3)_3$	$Ba(NO_3)_2$	$NaNO_3$
HCl					
H_2S					
H_2SO_4					
NH_4OH					

c. Treat 5 c.c. of each of the solutions named in *a* with hydrogen sulphide in excess. Make sure you have an excess, as suggested in *b*. Tabulate your results. Be sure the tube delivering the gas is clean before every test. For the action of hydrogen sulphide with ferric salts, *cf.* Experiment LXXII, *g*. For the conversion of *ferrous* ions into the *ferric* state, see Experiment LXXII, *d*.

d. Treat 5 c.c. of each of the five solutions with an excess of dilute sulphuric acid, and tabulate the results.

e. Repeat *d*, using ammonium hydroxide solution in place of sulphuric acid.

f. From the results tabulated in *b* to *e* devise a plan for identifying any one of the five nitrates, and of separating them, if they are all present in a mixture.

g. From previous experiments tell how you would determine whether a white, soluble solid given you was sodium *chlorate*, *nitrate*, *sulphate*, *carbonate*, *sulphite*, *acetate*, or *thiosulphate?*

h. If you wished to make a mixture of copper and barium salts, would you use copper *sulphate?* Why? Why not use barium *chloride* or ferric *chloride* solution if you wish to get a soluble mixture of the ions of these metals and those of silver?

i. Get from the teacher two or more unknown substances, and determine what metal or metals of the five named are present; also what acid.

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